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An Unaided Night Vision Instructional Program for Ground Forces

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U.S. Army Research Institute for the Behavioral and Social Sciences

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The report documents an instructional program on unaided night vision skills and knowledge critical to all ground force night operations. The program was developed jointly by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI), the Naval Aerospace Medical Research Laboratory, and the Naval Aerospace and Operational Medical Institute. A series of experiments conducted by ARI showed the program to be effective with both experienced soldiers and Infantry trainees. The program is presented in the dark using neutral density filters on 35-mm slides to allow individuals to dark adapt over a 30- to 45-minute instructional period. Demonstrations show what happens to vision at night as well as techniques to reduce visual illusions and other problems encountered at night. The report contains the instructional guide for the program, a separate summary of the program content, and a job aid to remind soldiers of critical night vision concepts and guidelines regarding use of their eyes during night exercises.

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An Undaided Night Vision Instructional Program for Ground Forces

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FOREWORD

Training is key to accomplishing military missions at night. Training materials and procedures must focus on basic skills as well as the special skills demanded by night equipment. The goals of the NIGHTFIGHTER program being executed by the Infantry Forces Research Unit (IFRU) of the U.S. Army Research Institute for the Behavioral and Social Sciences is to improve soldier, leader, and unit training for night operations. Several training products have emerged from this research.

The research product documented in this report is an instructional program on basic unaided night vision skills and knowledge critical to all ground force night operations. The program was developed under separate Memoranda of Agreements with the Naval Aerospace Medical Research Laboratory and the Naval Aerospace and Operational Medical Institute. In a series of experiments conducted by the IFRU, the program was shown to be effective with both experienced soldiers and Infantry trainees.

Units which used the program during its development were the Ranger Training Brigade, the 82d Airborne Division, and the opposing force at the Joint Readiness Training Center. The program is to be part of the U.S. Army Infantry School's Dismounted Battlespace Battle Lab's Night Fighting Training Facility and part of the exportable training package to be distributed by the Battle Lab.

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AN UNAIDED NIGHT VISION INSTRUCTIONAL PROGRAM FOR GROUND FORCES

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AN UNAIDED NIGHT VISION INSTRUCTIONAL PROGRAM FOR GROUND FORCES

Knowledge of how the eye functions at night and how to maximize unaided night vision are basics for the ground soldier. Unfortunately, much of the doctrine and training literature as well as training programs on unaided night vision have disappeared from current Army training materials. To reduce this training deficiency, in 1992 the Infantry Forces Research Unit (IFRU) of the U.S. Army Research Institute (ARI) joined with the Naval Aerospace Medical Research Laboratory (NAMRL) and the Naval Aerospace and Operational Medical Institute (NAMI) to develop an unaided night vision instructional program for ground forces. This program was based on one which had been developed previously by the NAMRL and NAMI for Navy aviators (Mittelman & Still, 1989).

This report contains the complete guide to the unaided program (Appendix A). This guide is the source document for instructors on how to prepare for and give the program. A job aid for soldiers, highlighting major unaided night vision concepts and guidelines in the program, is at Appendix B. A summary of program content is at Appendix C for use as a reference document. In addition, this report documents the major references and research on unaided night vision which provided the scientific foundation for the program content (Appendix D).

Program Description and Development

The program is presented entirely in the dark, using neutral density filters on 35-mm slides to allow individuals to dark adapt over a 45-minute instructional period. Neutral density filters decrease the intensity of a light without changing its color. The application of this technology to night vision training was developed by the Navy and is currently patent pending. The slides present basic information on unaided night vision. However, the unique feature of the program is the demonstrations which are provided via the specially-constructed slides. While the eyes gradually adapt to the dark, demonstrations show what happens to vision at night and techniques to reduce visual illusions and other problems encountered at night.

The most dramatic illustration of the extent to which the eyes become more sensitive at night as a result of dark adaptation is the contrast between the very first and the very last slides. These two slides are identical. However, when the slide is first presented it is not visible because the eyes have not dark adapted. On the other hand, the slide is very clear at the conclusion of the program, as the eyes have become 100,000 times more sensitive to the dark than they were initially.

The ground forces' program retains the basic structure of the aviation program. However, demonstrations directed specifically for aviators were removed, and ground demonstrations were added. For example, in the aviation version, the illustration in the first and last slides was a helicopter caught in wires. For the ground forces' version, the illustration is that of a fire team in the assault. The program demonstrations are described in Table 1.

Table 1
Demonstrations in the Unaided Night Vision Program

Demonstration	Description
Normal (Physiological) Blind Spot	Students scan a series of numbers and stop at the number which causes a large "X" to disappear in their peripheral vision - about 12-15 degrees off their axis of central vision.
Night (Central) Blind Spot	Demonstration 1. Students look directly at a dot of light. It disappears as they continue to stare at it. Demonstration 2. Students look at a model airplane as it is moves across the sky on a silhouette scene slide. Demonstration 3. Students look at the steeple of a church on a silhouette scene slide until the steeple disappears.
Technique to Overcome Night Blind Spot -- Diamond Viewing	A series of four dots create a diamond around the central dot in Demonstration 1. Students focus, in turn, on these four dots. The central dot then remains in view by using peripheral vision. Students use diamond viewing to maintain the airplane and the church steeple in the field of view.
Dark Adaptation - Increased Sensitivity of the Eyes	Contrast between the first and last slides which depict three attacking soldiers. Image not visible at first; clearly visible at end of program.
Visual Acuity	Words on the slides are never completely clear because of reduced visual acuity during darkness. Slides simulate acuity typical at twilight. A silhouette scene using trees, buildings, radio towers, and telephone poles/lines illustrates the inability to discriminate details of objects at night.
Autokinetic Illusion	Single source of light is presented. It appears to move as students look at it.
Technique to Overcome the Illusion	Apparent movement of the single light source is reduced by scanning back and forth between the light sources. Two light sources are presented to demonstrate this procedure.

Table 1 (*continued*)

Demonstration	Description
<u>Color Vision</u> Level of Illumination	Demonstration 1. Two slides in sequence which show six colors under two levels of illumination. Under low illumination only shades of gray can be detected; under high illumination colors are distinct.
Purkinje Shift - Shift in sensitivity of retina from yellow-red to blue-green when going from light- adapted to dark-adapted state	Demonstration 2. A red and green dot are presented. As they are viewed with increasing reliance upon peripheral as opposed to central vision, the red loses its intensity and may fade away. Eventually the colors in both dots disappear and only white light can be seen.
Strobe Light - Effects of short bursts of light on dark adaptation	Strobe light turned on while students continue to stare at silhouette of terrain on the screen in front of them. Dark adaptation not affected as long as student does not look directly at strobe.
Flood Light - Effects of looking directly at an intense light on dark adaptation	Overhead lights turned on while student covers one eye and stares at the lights with the other eye. Overhead lights turned off, the covered eye remains closed, and student examines terrain silhouette on the screen. Scene is now blurred due to loss of dark adaptation in the exposed or open eye. When the scene is then viewed with both eyes, the images are crisp and sharp because the dark adaptation in the covered eye has been maintained.

The slides and the program content were tailored to the ground force audience. Soldiers with extensive night operations experience were the source for most ground examples. After these soldiers observed the program, they were asked to give additional instances of the unaided concepts and perceptual demonstrations as well as other topics to include. Throughout program development, the Navy's expertise was used to ensure the scientific accuracy of the material.

The program has 38 slides. An illustration of each slide is printed in the guide (see Appendix A). This guide was modified throughout the development and evaluation processes based on feedback from students and instructors, and test results (Dyer, Gaillard, McClure, & Osborn, 1995). The final guide contains the instructional purpose for each slide and the concepts and examples to be stressed by the instructor. Detailed instructions on how to present each demonstration are given, and there is a suggested script for each slide. Guidelines on how to prepare and set-up the classroom for the program are provided.

The sequence of the program is as follows:

-Introduction
-Slide of troops, which cannot be seen
-Demonstrations on how colors change with varying levels of illumination
-Purpose slide
-Information on the eye; slides allow time for dark adaptation before the next demonstrations
-Information on the rod and cone cells
-Demonstration of normal (physiological) blind spot
-Demonstration of night (central) blind spot and diamond viewing technique
-Information on the three stages of dark adaptation
-Information on the dark adaptation process and the role of visual purple (rhodopsin)
-Information on protecting dark adaptation before night operations
-Information on protecting dark adaptation during night operations
-Demonstration of autokinesis
-Demonstration of the Purkinje shift (color perception)
-Demonstration of night blind spot and different effects of lights on dark adaptation
-Summary slides
-Slide of troops, which is now visible

Information on unaided night vision in current ground force field manuals (FMs) was compared to the unaided program in each of the areas identified in a front-end analysis (Dyer et al., 1995). This comparison showed the training program to be more complete, accurate, and detailed than the FMs.

The program does not train soldiers to scan habitually at night under stress and fatigue or to estimate distances at night under differing levels of illumination. Prior research in this area (Taylor, 1960) suggests that a different type of program would be required to train such skills.

Program Evaluation

The program was evaluated with soldiers who had differing years of service in the Army as well as with civilian and military instructors (Dyer et al., 1995). Two experiments were conducted which examined the extent to which the program increased soldiers' knowledge of unaided night vision beyond their current Army training and experience. These experiments also allowed an examination of program effects as a function of instructor familiarity with the program content. The civilian instructor, a member of the research staff, was very familiar with the content, whereas the military instructor was not as familiar. The military instructor also provided an assessment of the potential of program success in typical Army settings.

In these experiments, the program was found to significantly increase soldiers' scores on a test of unaided night vision, regardless of the time served in the Army and whether the instructor was military or civilian. Test scores increased 40% over the baseline measures. Important material on night vision was acquired better than less important material. The program

also had the strongest impact on soldiers' knowledge of demonstration-related material and technical information. The program did not, however, increase their ability to apply unaided night vision principles and concepts. Time in service for the different groups of soldiers participating in the experiments ranged from an average of 2.7 to an average of 10.9 years. The results also showed that soldiers' prior knowledge of unaided night vision tended to be fragmentary. Soldiers indicated little to no previous formal instruction on unaided night vision, which supported the front-end analysis findings of a lack of current training and instructional material in this area. These findings also support the view that field experience or "on-the-job training" is not necessarily an effective, nor efficient, means of acquiring knowledge of technical areas such as unaided night vision.

Dyer et al. (1995) also compared the knowledge gained from the program to that acquired from reading the same material, with no exposure to the visual demonstrations. This was analogous to determining what would be gained from reading a field manual with information on unaided night vision versus being exposed to a lecture-demonstration of the same concepts. Retention of the material over a 24-day period was examined as well. Participants in this experiment were Infantry one-station-unit-training (OSUT) trainees who had not yet started their basic training, and therefore had no previous training in or experience with military night operations. The two versions of the program were equally effective overall, on an immediate posttest as well as on the retention test. Posttest scores were 50% higher than baseline scores obtained from trainees who were given no instruction on unaided night vision. Retention of the material was high, as scores dropped very little, being 30% higher than the baseline group.

However, on both tests, the demonstration and text versions of the program had different effects upon trainees with differing levels of ability, as assessed by the General Technical (GT) score from the Armed Services Vocational Aptitude Battery (ASVAB). The GT score is a combination of verbal and arithmetic reasoning subtests from the ASVAB, and therefore, was assumed to provide a measure of general ability. The trainees with high GT scores benefited more from the text version than demonstration version of the program; trainees with low GT scores benefited more from the demonstration version than the text version. These results suggested that the effectiveness of the different versions of the program was a function of the learners' strengths and weaknesses. Trainees with the higher GT scores profited from the text version which demanded their verbal and reading skills, whereas the program version stressed auditory and perceptual skills. The reading skills of the trainees with the higher GT scores may have also been hampered in the program version as some of the word slides were difficult to read, being set at 20/50 visual acuity to simulate reduced visual acuity at night. Apparently, the auditory and perceptual aspects of the demonstration version of the program compensated for the more limited reading skills of the trainees with the lower GT scores, whereas the text version did not.

On the basis of this finding, a job aid highlighting basic concepts and guidelines, as well as a more detailed summary of the program content, were developed (Appendixes B and C). These appendixes can serve as instructional guides prior to receiving the program, as a "memory jogger" after the program, or as both.

All evaluations showed the program to be very effective and to fill a training deficiency in the Army's current doctrine and training literature, and training programs. The instructional features of the program were enhanced during development as well, resulting in an instructor-friendly set of training materials.

Unaided Night Vision Research

Major references and sources of information on unaided night vision are cited in Appendix D to provide a more complete documentation of the research in this area for users of the program and other interested individuals. General as well as specific sources are listed. Much of the basic or fundamental research on unaided night vision was conducted in the late 1930s and the 1940s. Some of the military research on unaided night vision conducted during World War II can not be easily obtained; the user must rely on secondary sources.

The Program Package

The program is an exportable training package. All the necessary instructional materials are included, making it easy to present the program in any military setting.

The package includes the 35-mm slides, the program guide, an audio tape of the instruction, a black box for the 35-mm projector, a red pen light, a strobe light, and scale models of an airplane and tank. A 35-mm carousel projector, without an autofocus lens, should be used to present the program. The black box covers the carousel projector and prevents light from the projector from inhibiting full dark adaptation by the students. The pen light, strobe light, and airplane and tank models are training aids used in the demonstrations. The audio tape is for preparing instructors to give the program. It can substitute for an on-site instructor when a trained instructor is unavailable. However, the preferred instructional mode is with an experienced instructor, as this provides the best means of interacting with students and conducting the demonstrations.

Both experienced and inexperienced soldiers can profit from seeing the program. The knowledge gained can be applied directly by soldiers to maximize the use of their eyes at night and applied by leaders to refine their standing operating procedures for night operations. It is recommended that the program be repeated periodically to maximize retention, understanding, and application of unaided night vision principles and skills during the conduct of night operations.

REFERENCES

Dyer, J. L., Gaillard, K., McClure, N. R., & Osborn, S. M. (1995). Evaluation of an unaided night vision instructional program for ground forces (Technical Report 1032). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Mittelman, M. H., & Still, D. L. (1989). Unaided night vision training guide. Pensacola, FL: Naval Aerospace Medical Research Laboratory and Naval Aerospace Medical Institute.

Taylor, J. E. (1960, December). MOONLIGHT I: Identification of stationary human targets (HumRRO Research Memorandum). Fort Benning, GA: Human Resources Research Office. U.S. Army Infantry Human Research Unit.

APPENDIX A

UNAIDED NIGHT VISION GUIDE FOR GROUND FORCES

Co-Developed by

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PENSACOLA, FLORIDA

NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY
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1995

UNAIDED NIGHT VISION GUIDE

OVERVIEW

This training program provides information on unaided night vision, that is, the operating at night without night vision goggles or other night observation devices. As operational requirements demand more night operations, it is absolutely necessary to educate all about the potential hazards and physical limitations to be encountered in the unaided night environment. The training program:

1. Presents information on how the eye works at night
2. Allows individuals to experience nighttime visual illusions
3. Shows how to reduce visual illusions
4. Shows how to protect and maximize vision at night

The program is designed to be presented in a dark room, allowing for maximum dark adaptation within a 30 - 45 minute time frame. The slides used in the program are laminated with neutral density filters which allow them to be presented in a timed sequence which facilitates dark adaptation. **DO NOT CHANGE THE SEQUENCE OF THE SLIDES**. In this guide, each demonstration slide is shown, followed by a brief summary of important points and a suggested script

INSTRUCTOR PREPARATION

It is strongly recommended that the individual to present the program see it as a "student" first. In this way, the instructor will have personally experienced the visual illusions and other phenomena which must be explained. This experience is critical to interacting effectively with program participants. The instructor must be very close to the screen to give the program and cannot experience the visual illusions at this distance.

Finally, the instructor should conduct a "dry-run" of the program to a small group of individuals, to become comfortable with presenting in the dark.

PROGRAM SETUP

CHECKLIST OF REQUIRED MATERIALS:

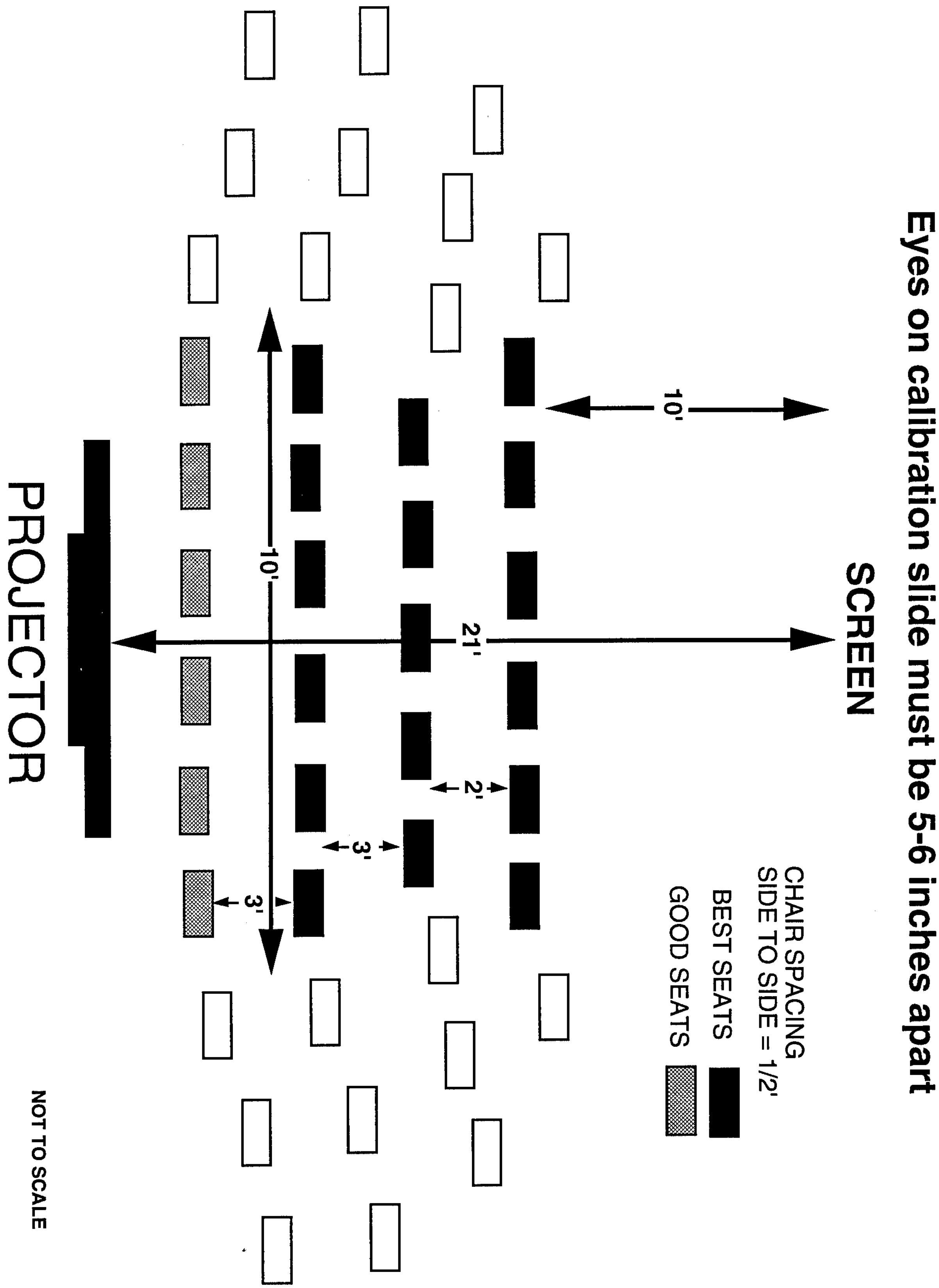
The following materials must be available in order to conduct the program. Place a check mark (√)) in the box to the right after you have obtained each item.

Required Materials	(√)
Unaided Night Vision Slides in Carousel Tray	
12' wide by 6' high area of flat wall painted with white or pastel paint to be used as a projection screen. (A projection screen can also be utilized.)	
2" by 2" Carousel slide projector Black box for the projector to mask light Black cloth may be used to mask light leaks Standard 5" lens or zoom lens	
SDU-5E Strobe Light (Model 4FWA)	
Penlight, with red and white filters or equivalent, or comparable pointing device	
Aircraft or tank model(s), 1/72 scale, painted flat black, on 1/4 inch diameter or smaller dowel holder	
Red lens flashlight to aid in finding things in the dark	

To achieve maximum effectiveness of all the desired visual demonstrations, it is essential to present this lecture in a **very dark** room. Rooms without windows are preferable. If such a room is not available, then you can make the room sufficiently dark by covering all the windows with aluminum foil, and sealing the edges with masking or duct tape. Also, cover all cracks around doors which can let in light, Exit signs, etc. To check whether you have made the room light proof, turn off the lights, let your eyes dark adapt for a few minutes and search for any remaining sources of light. It is preferable to have overhead lighting in the room which can easily be controlled from the front of the room.

The room set-up should conform to the optimum room layout as illustrated on the next page. That layout accommodates about 30 people. Variations from that layout will cause some participants to miss seeing some of the illusions.

Multi-voltage projectors must be set on the 60 cycles setting when used with the 60 cycles current (all US). If incorrectly set, projector can **overheat** and **destroy** slides.


Eyes on calibration slide must be 5-6 inches apart
SCREEN
CHAIR SPACING
SIDE TO SIDE = 1/2'
BEST SEATS
GOOD SEATS
10'
21'
10'
2'
3'
3'
PROJECTOR
NOT TO SCALE

Projector Adjustments Using Unaided Night Vision Calibration Slide

To be effective, the slides must be in focus, the correct size, and proper brightness. The calibration slide makes these adjustments simple. When the calibration slide is in focus, the demonstration slides will also be in focus. When the distance between the two eyes in the calibration slide is correct, the image size of the demonstration slides will also be correct. When the image size is correct, the brightness will automatically be correct.

In order to set-up the projector accurately, follow the steps below in the order listed. Place a check mark (√) to the right after you have completed each step.

Steps Required for Projector and Slide Adjustment	(√)
1. Turn on the projector and project and focus the calibration slide on the projection wall/screen. Calibration slide is in the white slide mount. a. **Use the manual focus. Do <u>not</u> use auto-focus.** b. Measure the distance between the centers of the two eyes. c. Adjust the distance of the projector from the projection screen or wall or adjust the zoom lens to make the **<u>distance between the centers of the two eyes between 5 and 6 inches.</u>** (If the image size is too small, the projected images will be too bright. If the image size is too large, the images will be too dim.)	
2. Cover the projector with one of the two covers which came with the slides. a. You can drape the black cloth to block stray light from the projector from reaching the projection screen/wall. b. Be careful not to block the projector's ventilation.	
3. Set the projector bulb brightness to **<u>LOW</u>** (be sure that the bulb **does not exceed 300 Watts**). **Warning: Projector will overheat and destroy slides if the bulb brightness is set at HIGH.**	
4. Perform a test run through the program. You can slightly increase or decrease the size of the images or change the projection bulb setting to make the demonstrations work. At this point you should be 'good-to-go.'	

PROGRAM PRESENTATION

The program takes from 30 to 45 minutes. Stand at the front of the room while presenting the slides and conducting the demonstrations. All slides can be seen from this close distance. An assistant may be needed to run the slide projector or assist with the lights.

Because the words on the **slides will not always be clear or legible (in focus) to everyone, be sure to cover each of the points on the slides.**

The pages in this guide contain three types of information on each slide:

1. A drawing of the slide
2. Major point(s) to stress, major purpose of the slide, and/or how to conduct the demonstration
3. Possible briefing script

The examples given in the script are very important. They make the training meaningful, and will improve the understanding and retention of the material.

INTRODUCTION TO THE LIMITATIONS OF NIGHT VISION

INSTRUCTIONS: Room lights should be on when giving the introduction. They should not be dimmed.

The goal of this section is to establish the need for training on night vision with the naked eye and to summarize the objectives of the program. Even though many units have night observation devices, they must often function without them. Night vision goggles and/or weapon scopes are not available for everyone; night vision goggles can fog up making them unusable. Under some illumination conditions, such as full moonlight, goggles are not always needed. In addition, although other senses, primarily your ability to sense smells and sounds, play a critical role at night, this program focuses on unaided vision only.

Eighty percent of a person's sensory input is obtained from the visual system. Under many conditions, vision is the primary sense which tells troops about their surroundings. All forces need good visual acuity and depth perception for operations and detection of the enemy (both airborne and on the ground). They need good color vision for identifying signal flares and chem lights, and must have an understanding of the limitations of night vision if they are to function effectively in night operations. During this 30 - 45 minute presentation, we will show participants the problems the unaided eye experiences under nighttime conditions with respect to flash blindness, the ability to see colors, visual acuity, and a night vision blind spot.

Possible Script on next page.

Possible script:

Ground forces must operate effectively at night. This was demonstrated vividly during our most recent combat operations. Although operating at night has definite advantages, it is also difficult. Your eyes do not work as well as during the day. In fact, at times, they may seem to play tricks on you. This training demonstrates how the dark affects your eyes and how they work in the dark. It was developed specifically for ground forces.

Your eyes are critical to your performance. You need to be aware of the constraints your eyes place upon you at night, because eighty (80) percent of your sensory input comes through them. Even when night observation devices and goggles are available, there are always circumstances where ground forces must operate without them; that is, with "unaided night vision." Your abilities to hear sounds and to detect various smells are also very critical at night. However, we focus only on unaided vision in this training. The program focuses on the basic skills necessary to operate confidently at night, independent of devices.

During the next 30 to 45 minutes, we will demonstrate some of the problems your unaided vision can experience at night. We will examine your ability to see crisp and clear images; that is, your visual acuity. Your ability to see colors and a "night blind spot" are covered as well. Ways to reduce night vision problems will be shown. You will be shown how to scan so you can see objects more clearly, and how to react to different types of lights to protect your dark adaptation.

This training will be conducted in the dark. However, your eyes must first adapt to the dark for the training demonstrations to be effective. To allow time for dark adaptation, some interesting information on the human eye is presented first.

The slides will not always appear clear to you. It takes a while for you to dark adapt, and your visual acuity at night is not as good as during the day.

INSTRUCTIONS: Turn off room lights BEFORE presenting next slide.

DEMONSTRATION OF THE LIMITATIONS OF NIGHT VISION

SLIDE 1: **Troops**

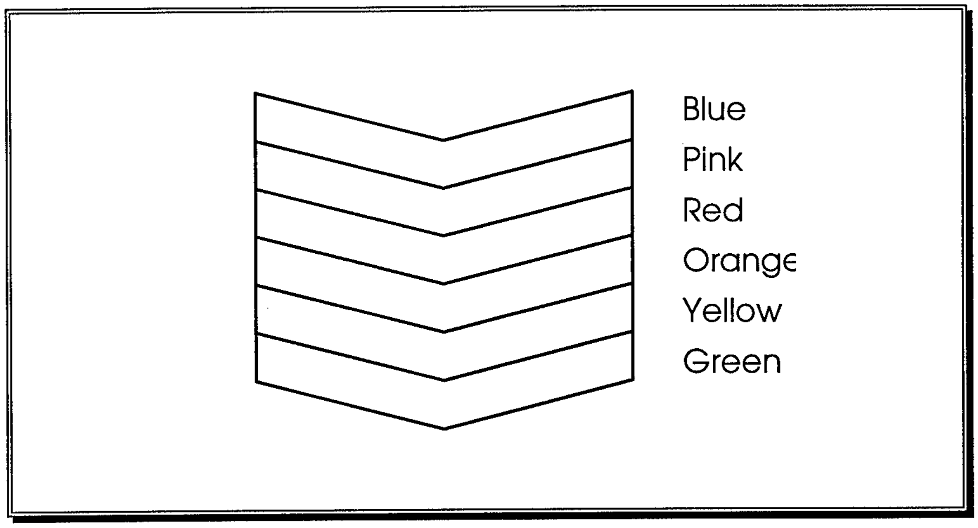
The goal of this section is to describe the relevant structures of the visual system and then demonstrate the effect of these structures on night vision.

> This slide will be imperceptible to the class. Explain to the students that there really is something up on the screen, but they do not see it because they are not yet totally dark adapted. Point out that it takes approximately 30-45 minutes to totally dark adapt.

Possible Script:

Does anyone see the picture projected on the screen?

There really is something up there. You cannot see it at this time because you are not yet dark adapted. It takes the eyes anywhere from 30 - 45 minutes to acclimate to the dark.



SLIDE 2: **Visual Spectrum (dark)**

This slide is designed to bring everyone up to a minimal level of dark adaptation. It demonstrates that under low illumination levels only various shades of gray are seen in the color spectrum. Some people in the class will perceive a dark "V" in the middle of the slide rather quickly, while others will see nothing. After a couple of minutes, everyone should be able to see the dark "V". They may even be able to differentiate colors slightly. When everyone can perceive at least the dark band, proceed to the next slide.

Possible script:

As I change to the next slide, look toward the center of the screen. People in the front 2 rows may start to see something up there. People who are a little older, people who smoke, or people who may not be in great physical shape will take longer to dark adapt or see things up on the screen. The further back you are in the room, the longer it may take to see.

For those of you in the back of the room, do you see anything on the screen? Let me know when you start to see something. Remember, you should be looking toward the center of the screen. (Pause).

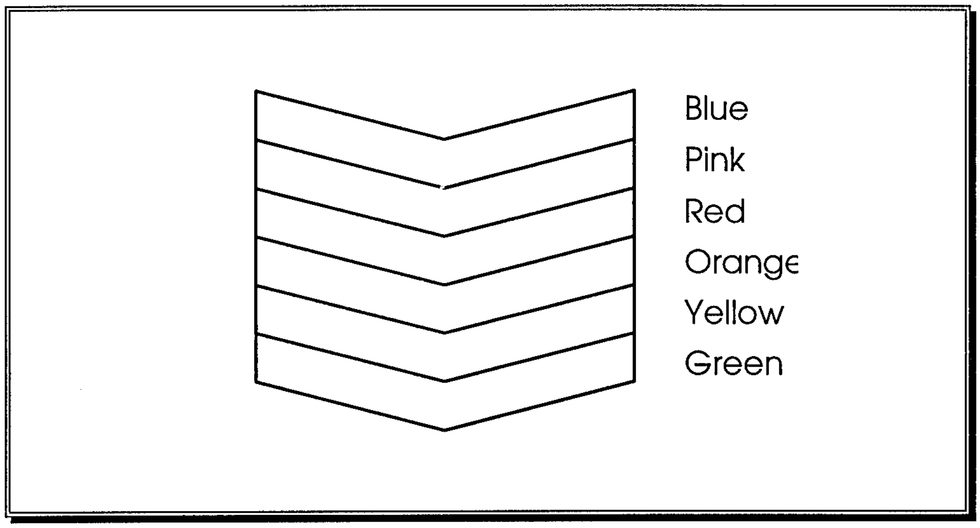
It's similar to walking into a movie theater when it's very dark. You can't see things at first. As you sit there a while your eyes will adapt, enabling you to see more and more as time goes on. That is what you are going to do during the course of this training. You are going to let your eyes dark adapt, or get used to working in the dark. Once dark adapted, you will experience the different tricks your eyes can play on you. (Proceed to next page.)

Now, most of you should see something. For those seated towards the back, do you see something? Explain what you see. (Pause and repeat name of shape - a "V" or a chevron or a slanted line.) What other colors do you see? (Pause and repeat names of colors given.)

At night , colors don't look as distinct or as real as they would under brighter light levels. I assume everyone can see the chevrons or "Vs" in the center of the slide, but no one can really correctly guess all the colors.

Let me show you the same slide, but with a slightly higher level of illumination.

INSTRUCTIONS: Do not proceed to next slide until everyone can perceive at least the dark chevron.



SLIDE 3: **Visual Spectrum (brighter)**

This slide demonstrates that under greater levels of illumination you will be able to perceive a great many more colors, especially the reds.

It will be helpful to switch between this slide and the previous slide to help make important comparisons between the two light levels.

Possible Script

Now what do you see on this slide?

The chevron you saw first on the previous slide, the black one, is actually red.

The lighter chevrons looked brighter shades of gray, but none of them looked green, none of them looked red, and none of them looked yellow; they just appeared as varying shades of gray.

If the red chevron was not bordered by the two lighter colors, it would have been totally invisible. Reds will be almost invisible at night. The reason Red Crosses are on white backgrounds on tents or vehicles is so they can be more easily seen at night.

Under low light levels, the longer wave lengths of light, such as the reds and oranges, are hard to see and will appear dark. On the other hand, greens and blues will appear brighter.

Objectives

- Understand eye at night
- Experience visual illusions
- Learn how to see better
- More efficient night fighter

SLIDE 4: **Objectives**

The objectives of the training program are:

1. Understand how the eye works at night
2. Have participants experience night visual illusions
3. Learn how to see better at night without the aid of night vision devices
4. Ultimately, become more efficient night fighters

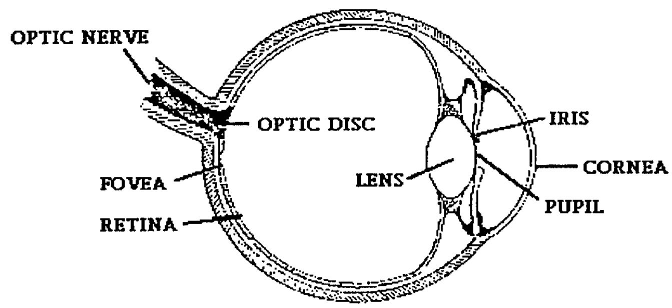
Possible script

Now that I have your attention, let me explain what you will learn when you are done with this training session. First, you will have a better understanding of how the eye works at night. This is important for you to understand so that you can use your eye to the greatest advantage at night.

You will spend some time on the anatomy of the eye to give you time to dark adapt. Then, you will actually experience some of the visual illusions common at night and learn techniques to deal with them.

By knowing how the eye works at night and experiencing the night vision illusions, you will learn how to see better at night and ultimately become a more effective night fighter.

THE EYE



SLIDE 5: **Human Eye Diagram**

In order to function effectively at night, individuals need to know how the eye works at night. This section of the training program identifies and describes the major parts of the eye as well as the function each has in night vision. Six parts are discussed: the cornea, the iris, the pupil, the lens, the retina, and the optic nerve. They should be presented in this order, as it corresponds to the progression of light through the eye (i.e., light first passes through the cornea and eventually hits the retina and signals are sent to the brain via the optic nerve).

The major points to stress on this slide of the human eye are:

- The change in the size of the pupil at night, the effect this has on visual acuity, and the resultant need to wear glasses at night to improve vision.

- The lens helps you focus on near objects. The ability of the lens to focus decreases with age. Objects illuminated by red lights require more focusing power than objects illuminated with blue-green lights. Older people have more trouble reading, especially under red illumination and red lit dials, than younger people.

- The central and peripheral portions of the retina. The cones, which are throughout the retina, are responsible for central, clear vision. Rods, which are on the peripheral retina, are responsible for peripheral vision and as well as most of your night vision. Lack of rods and cones, where the optic nerve inserts into the retina, creates the "normal blind spot."

Point to each part of the eye as you describe it. At this time the words on the slides can still be quite blurry to many individuals.

Possible Script:

In order to better understand how the eye works at night you need to know some anatomy.

<u>Cornea</u>. Light enters the eye through the clear portion of the eye called the cornea. The cornea has the major responsibility of bending light so that it focuses clearly at the back of the eye. The cornea is also very sensitive to pain. If you get a piece of sand in your eye, the cornea is what hurts. When you wear contact lenses, the contact lenses fit over the cornea.

<u>Iris</u>. Behind the cornea is the colored part of the eye called the iris.

<u>Pupil</u>. In the middle of the iris is a hole, called the pupil. At night the pupil gets larger in order to let more light into the back of the eye. In bright sunlight, the pupil gets smaller, but at night when the pupil gets larger, light which normally might focus clearly on the back of the eye may focus imperfectly on the back of the eye because of the eye's imperfect optics. Images can become blurred. This is especially noticeable if you need glasses to see clearly. Even individuals with weak prescriptive glasses, who may not need their glasses to see clearly during daylight, need glasses to see clearly at night. During daylight the small pupil size helps light to focus clearly on the retina. At night, however, the pupil becomes larger, reducing this focusing capability of the eye. Wearing glasses at night counters this effect. <u>It is very important for individuals with weak prescriptions to wear their glasses in order to see the best that they can at night.</u> Leaders need to be sure that individuals with weak prescriptions are wearing their glasses at night.

<u>Lens</u>. Right behind the pupil is a saucer shaped structure called the lens. The lens has a couple of different functions. First and foremost, the lens helps to focus light in the back of the eye.

Second, the lens gives you the ability to focus objects located closer than 20 feet. This is called accommodation. What happens as you look at things up close is that the shape of the lens changes, causing it to work as a magnifier. This is how the eye adjusts its focus so that objects 16-20 inches away from us become clear. Unfortunately, as you get older, this process of accommodation doesn't work as efficiently. People who are over the age of 40 have more difficulty focusing on close objects. This occurs because the lens does not change shape as easily. Therefore, older people need to wear reading glasses or bifocals. **(Proceed to next page)**

The lens focusing system does not work well at night. Under night time conditions the lens fails to totally eliminate blur. Additionally, under red lighting conditions, it is even more difficult to focus because red lights make us more farsighted.

<u>Retina</u>. When light finally does make it to the back of the eye it focuses in the area called the fovea. As we will discuss later, the fovea is responsible for good crisp vision.

The rest of the retina is called the peripheral retina. This is used for your peripheral vision and is primarily responsible for motion detection and your night time vision.

There are two types of light receptors on the retina - cones and rods. The cones are concentrated in the center of the fovea, and decrease in number as you go away from the fovea or the center. On the other hand, there are no rods in the middle of the fovea; they are concentrated on the peripheral retina and increase in numbers as you go away from the fovea.

<u>Optic Nerve</u>. The peripheral retina is also where the optic nerve inserts in the back of the eye, connecting the optic nerve to the brain. There are no light receptors at this point, resulting in a "normal blind spot." The "normal blind spot" is demonstrated later in this program.

Eye Summary

- Larger pupil = blurry images
- Lens works harder with red light
- Fovea = daytime vision
- Peripheral = night time vision

SLIDE 6: **Eye Summary**

This slide summarizes the key points about the previous diagram. Ensure that you stress that when the pupil is larger, the optics of the eye are less forgiving and require those who wear glasses to see at distance to use them at night. Red lighting makes it more difficult for people to see up close, causing the lens to work harder. The fovea is responsible for most of your daytime vision while the peripheral retina is responsible for your nighttime vision.

Possible Script:

It is important to remember the following points about how the eye functions at night.

When the pupil enlarges at night, images become blurred. Individuals who require glasses to see at distance during the day should wear them at night to reduce this blur. Red lighting at night makes it more difficult to see up close, causing the lens to work harder.

The fovea, the central part of the retina, is responsible for most of our day time vision. On the other hand, the peripheral retina is responsible for our night time vision. The next slides deal with the light receptors on the central and peripheral retina.

Two Types of Light Receptors

- Cone Cells
- Rod Cells
- Name corresponds to shape

SLIDE 7: **Two types of light receptors**:

There are two types of light receptors in the eye. Cone cells are responsible for daylight vision. Rod cells are responsible for night and peripheral vision. They have received their names based on the shapes of each cell type.

Possible Script:

As we move to the next slide we discuss cells or receptors on the retina in more depth.

There are two types of cells in the back of the eye, cone cells and rod cells. The cone cells are primarily responsible for daytime vision, while the rod cells are primarily responsible for night vision.

You will spend some time on the rods and cones because most of the differences between your daytime and night time vision result from the fact that they function differently.

We will talk about the cone cells first.

<u>Cone Cells</u>

- Sunlight to Full Moonlight
- 20/15 Vision
- Color Vision
- Fast acting

SLIDE 8: **Cone Cells Function**

Stress the time periods when cones function and the visual capabilities they provide:

Sunlight to full moonlight
Good visual acuity
Color vision
Fast reaction times to visual stimuli

Also explain what is meant by someone having 20/20, 20/100, or even poorer vision. This concept is important because throughout the program references are made to the degree of visual acuity at night as illumination decreases. See Possible Script below.

Possible Script:

Cone cells function during the day and under full moonlight at night. If the light level gets below full moonlight, the cone cells cannot function.

The cone cells are responsible for your good, clear, crisp 20/20 or 20/15 vision, for your good visual acuity.

What does having 20/20 vision mean? It means that if an object is placed at 20 feet, a person with 20/20 vision can see it clearly at that distance. On the other hand, if you have 20/100 vision, that means that you can see at 20 feet what someone with 20/20 vision can see at 100 feet. <u>You must be closer to the object to see it clearly.</u> The bottom line is that if the second number is big, your vision is poor; you have problems and need glasses to correct these problems.

Cone cells are responsible for color vision.

They are fast acting, which means as soon as they sense light, it is processed back to the brain.

Cone Cells - continued

- Approximately 7 million
- Everywhere on retina
- Central concentration
- Responsible for night blind spot

SLIDE 9: **Cone Cells Function (continued)**

This slide completes the description of the cone cells.

Possible Script:

There are approximately 7 million cone cells located throughout the retina. The cone cells are located everywhere on the retina, but are concentrated in the fovea or the area of central vision where your best visual acuity occurs.

In fact, the cone cells are the only cells in the middle of the fovea.

Since they are the only cells in that area, they are responsible for the "Night Blind Spot." The "Night Blind Spot" will be demonstrated later in the program.

Rod Cells

- Effective at night
- 20 times more rods than cones
- 10 times worse vision (20/200)
- Not used for central vision

SLIDE 10: **Rod Cells Function**

Emphasize that rod cells operate only at night. Although there are 20 times more rods than cones in the retina (approximately 120 million), visual acuity is 10 times worse than with cones. The best visual acuity you can expect is 20/200. Explain the impact of having 20/200 vision at night (see Possible Script below). Finally, stress that the rods are concentrated in the peripheral retina and are not used for central vision.

Possible Script:

The other type of cells in the back of the eye are called rod cells. They are most effective at night.

There are 20 times more rod cells than there are cone cells.

But the visual acuity you get with rod cells is 10 times worse than can be obtained with cone cells. The best visual acuity you can hope to obtain while using rod vision is about 20/200. That's the big "E" on an eye chart!

What does this mean for your night vision, when there is little moonlight or starlight available? 20/200 means that for an object which you could see clearly during the day from a distance of 200 feet, at night you must be 20 feet away before you can see it.

As we mentioned earlier, rod cells are not used for central vision. They are not in the middle of the fovea. They are concentrated on the periphery of the retina.

Rod Cells - continued

- No Color Vision
- Sensitive down to small amounts of light
- Slow acting

SLIDE 11: **Rod Cells Function (continued)**

This slide completes the description of the rod cells. Each point on the slide should be mentioned. The fact that color cannot be perceived with rod cells is important. The consequences of this are demonstrated later in the program.

Possible Script:

Colors cannot be seen with rod cells. They just see black, white, and shades of gray.

On the positive side, rod cells are sensitive to very small amounts of light, which is why they work so effectively for night vision.

They react more slowly to visual stimuli than the cones. This means that it takes longer for the light signal to be processed in the rod and sent to the brain.

Two Blind Spots per Eye

- Normal
- Night

SLIDE 12: **Two Retinal Blind Spots**

The next seven slides are on the blind spots in the eye. Demonstrations of each are given. There are techniques which individuals can use at night to overcome the effects of the "night blind spot." These are demonstrated as well. It is critical that everyone viewing this program understand and can apply these techniques (diamond viewing, scanning) effectively at night.

Possible Script:

As I alluded to earlier, you have two blind spots in each eye.

You have a "normal blind spot," and you have a "central night blind spot."

Normal Blind Spot

- Always present (day and night)
- Optic nerve insertion
- No light receptors

SLIDE 13: **Normal Blind Spot**

Stress that the "normal blind spot" is always present - day or night. It is also called the physiological blind spot. Remind students that it is caused by the insertion of the optic nerve in the back of the eye. At that point, there are no light receptors. The next slide demonstrates the "normal blind spot."

Possible Script:

The "normal blind spot" is always present, day and night. As you recall, it is caused by the lack of light receptors where the optic nerve inserts into the back of the eye.

I would like to demonstrate the "normal blind spot" for you.

1 2 3 4 5 **X**

SLIDE 14: **"Normal Blind Spot" Demonstration**

Demonstration Technique

The following procedures should be followed in demonstrating the "normal blind spot."

Have the students **<u>cover their left eye.</u>** This demonstration will **<u>NOT</u>** work if they cover their right eye or if they have both eyes open.

Ask them to fixate on the number 1 on the slide with their right eye. If they <u>cannot</u> see the "X" at this point while fixating on the 1, point out that the position of the "X" corresponds to the "normal blind spot." If they can still see the "X" while looking at the 1, have them shift their gaze to the next higher number (to the right). If they still can see the "X", have them shift their gaze to the left of the 1 until the "X" disappears (the further back the students sit, the further left they must look). The angular distance from the number they are fixating on while the "X" disappears to the actual "X" will be about 12 - 15 degrees.

At this point in the demonstration, students may also be experiencing their "night blind spot." Do not be surprised if they indicate that the number they are staring at disappears or fades away.

Possible Script on next page.

Possible Script:

On this slide you should see the numbers 1, 2, 3, 4, and 5, and an X on their right.

Would everyone in the room please cover your left eye. Slowly scan at numbers 1 - 5 on the slide until the big X disappears. You may have to look slightly to the left of the number 1, depending upon where you are sitting in the room.

When the X disappears, that position in space corresponds to the "normal blind spot." It is about 12-15 degrees off from the number you are looking at directly in front of you.

Do you think this will adversely affect your ability to function in the field? Uncover your left eye and tell me what happens to the X. (Pause) It reappears.

Why don't you experience such blind spots during the day during normal work? The "normal blind spot" is not really a factor unless you are using only one eye, because the visual fields of both eyes will overlap so that what one eye doesn't see the other eye will see. You will never notice the "normal blind spot."

Later in this program I will describe to you certain times where you must cover an eye to preserve your dark adaptation. During these times, you will only be using one eye, and therefore must compensate for the "normal blind spot" by scanning more vigorously.

We will describe a scanning method later in the program.

Night Blind Spot

- Both eyes
- Only at night
- No rods for central vision

SLIDE 15: **"Night blind spot"**

Mention that the "night blind spot" is present only at night, under starlight or lower light conditions. Also explain that it is located in the central area of the retina, and why it occurs (see Possible Script below). The technical name for this spot is the central blind spot. The next slide then shows what can be missed during night operations because of the "night blind spot."

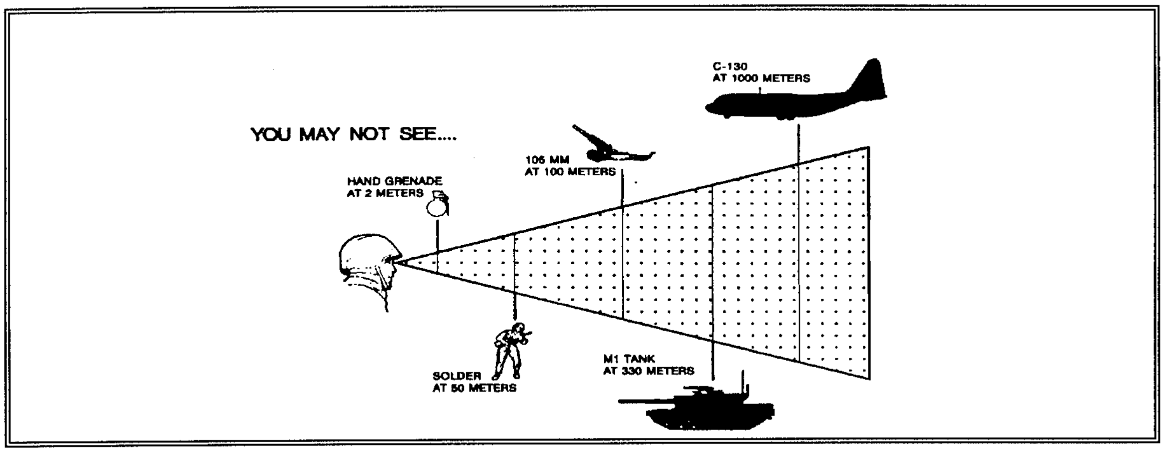
Possible Script:

When you stare at something at night, under starlight or lower levels of illumination, it can disappear or fade away. This is a result of the "night blind spot." It is critical that troops know they have a "night blind spot" and what they must do to overcome it.

It occurs only under starlight and lower levels of illumination. It affects both eyes at the same time and occurs when using the central vision of both eyes.

Why do you have a "night blind spot?"

When you stare at something, you are using your central vision, the central part of the retina, the fovea. The majority of light receptors on that part of the retina are the cones, and they do not function under low levels of illumination. However, the rod cells, which do function at night, are not concentrated in the fovea. Consequently, you cannot see objects at night when you stare at them; that is, use your central vision.



SLIDE 16: **"Night Blind Spot" Description**

This slide provides examples of objects that can be missed at night because of the "night blind spot." The "night blind spot" is approximately 2 inches at arm's length, which is about the same size as an outstretched adult thumb. Point out each object and its distance since the objects and words on the slide may not be clear to everyone in the room.

Possible Script:

What are the consequences of the "night blind spot" for military operations?

As you can see from the slide, the "night blind spot" can hide certain things. If you stare at these objects, at these distances, they will disappear.

A hand grenade 2 meters from your eyes might not be seen.
An enemy soldier at 50 meters might not be seen; a howitzer at 100 meters might not be seen. An M1 tank at 330 meters might be missed.
You may miss something as large as a C-130 aircraft 1,000 meters away from you.

As shown on this slide, larger and larger objects are missed as distances increase.

So, if you are looking directly at something at night, you may miss it because of the "night blind spot." When following others at night in a file, individuals have reported cat-eyes on the back of helmets disappearing, and that staring at mini-chem lights caused them to disappear.

<u>To Maximize Night Vision:</u>

<u>Use Diamond Viewing</u>

<u>Look Around Objects</u>

SLIDE 17: **Night Vision Viewing Techniques**

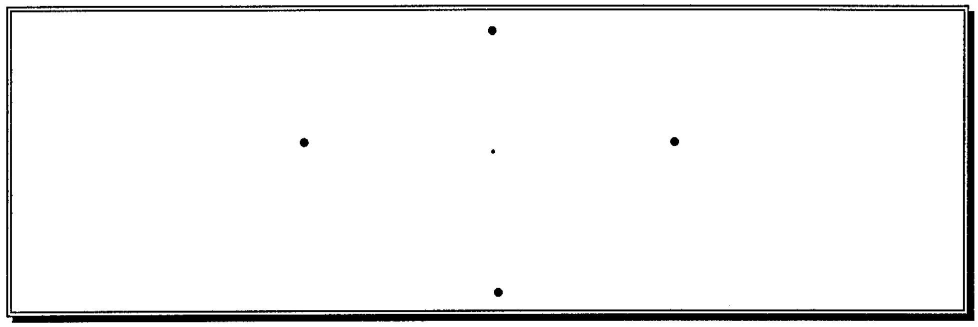
One objective of the training program is to train individuals to minimize the effect of their "night blind spot" at night. The technique demonstrated in the program is called "diamond viewing" and involves a very simple principle of looking to all sides of objects in order to see them clearly with your peripheral vision. Therefore, emphasize that in order to maximize your night vision for target acquisition and to avoid collisions, it is imperative that ground forces look to the sides of objects in order to see them better.

Possible Script:

In order to work around the "night blind spot" there is only one thing to do: look to the sides of objects you are trying to find or follow.

Don't stare. This is the only way for you to maximize your night vision. A good technique for peripheral viewing is called "diamond viewing."

It is similar to the off-center vision technique you may already have been taught in marksmanship.



SLIDE 18: **Diamond Viewing Technique Demonstration**

Use the following <u>demonstration technique</u>:
Have the students look at the center of the diamond and ask if they can see the central spot. It should disappear for them as they stare at it. Then have them look at the corners of the diamond, looking at each of the four dots in turn. Note that the dots are about 90 degrees apart. Stress that the diamond viewing technique is different than what they do in the day to see objects more clearly. In addition, cite the examples given in the Possible Script on the following page to show the importance of this technique.

Possible Script:

There are 5 dots on the screen. I would like for everyone to look at the dot in the center and tell me what happens. (Pause). It disappears.

Now look up at the large dot on top for 2 or 3 seconds and then work your way around the diamond. Tell me what happens to the dot in the middle. (Pause). The central dot seems a lot brighter.

When you look up at the dot on the top, you are placing the smaller, central dot on your peripheral retina. You are now using your peripheral retina to view the target. Work around the diamond, keeping the center dot in view. This is called "diamond viewing."

If you look directly at the dot in the middle of the diamond, you will lose the target because your "night blind spot" will not allow you to see it. You will practice this some more later.

The point is that when you stare directly at an object at night, it will disappear. You must view it peripherally instead, which is just the opposite of what you do during the day in order to see an object clearly. Just move your eyes slightly to see peripherally. It is not necessary to move your head.

Even while moving, troops have reported it is better to use peripheral vision when looking at the person in front of you. You see him more clearly. In addition, the need to watch for tree limbs, signals, and holes in the ground at night reinforces the importance of scanning. Diamond viewing is exactly the opposite of what you have always done to see something clearly. In the day, you stare or look at something intently to see it.

When you are under stress at night, concerned about a break in contact during movement, etc., you may resort to habit. Thus you may tend to stare at the person in front to avoid losing contact. But you should do just the opposite - use a scanning pattern, such as diamond viewing to maximize your ability to see troops ahead of you.

Also, exhausted people resort to habit and tend to stare and not scan. If you are staring, that means you are not using your peripheral vision because you are not scanning. Remember, you are going to be susceptible to that "night blind spot" if you stare. Fatigue does not appear to affect your visual acuity, but rather your ability to concentrate and therefore your scan pattern. It is important to enforce rest cycles so individuals on patrols, on observation posts, on security, etc. will use diamond viewing and not be susceptible to the "night blind spot."

Three Stages of Adaptation

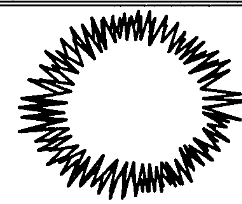
- Daylight
- Twilight
- Night

SLIDE 19: **Three stages of Adaptation:**

The next seven slides discuss three stages of dark adaptation. Military night operations are conducted under both twilight and night levels. Major points to emphasize are how visual acuity, color perception, and reaction time change as the illumination becomes less, and what light receptors (rods and/or cones) function under each of these three conditions.

Possible Script:

As seen on this slide, there are three stages of dark adaptation to discuss which will help to explain how the eye works at night.



Daylight Vision

- Maximum lighting
- Central and peripheral vision
- All Cone vision

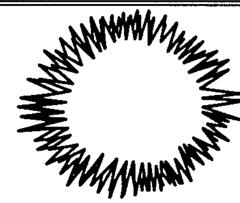
SLIDE 20 **Daylight Vision**

Mention each of the points on the slide. Daylight vision is also known as photopic vision.

Possible Script:

The first stage is daylight vision. This occurs under maximum lighting conditions such as when the sun is shining or in a well lit room.

You are using both your central and peripheral vision, but it is all cone vision. There is no rod vision.



Daylight Vision - continued

- Best visual acuity
- Best color vision
- Best reaction time

SLIDE 21: **Daylight Vision (continued)**

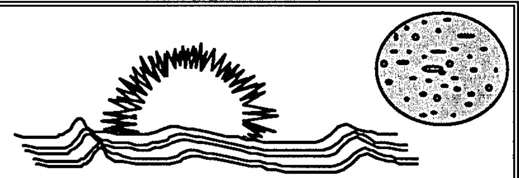
This slide completes the basic characteristics of daylight vision. These characteristics, visual acuity, color vision and reaction time, are also discussed on the twilight and night vision slides.

Possible Script:

Because you are using all cone vision, you have your best visual acuity; that is 20/10, 20/15, and 20/20 vision.

You have your best color vision. Colors look most vivid under daylight conditions.

You also have your quickest, best reaction time because you are using all cone cells.



Twilight Vision

- Dawn and Dusk
- Under jungle canopy
- Central and peripheral vision
- Rods and Cones

SLIDE 22: **Twilight Vision**

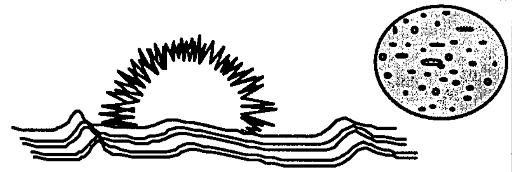
The next two slides are devoted to twilight vision. This is also known as mesopic vision. Many military operations are conducted under these conditions. Be sure to cite the variety of conditions under which twilight vision occurs as listed in the Possible Script below.

Possible Script:

The next stage of adaptation is twilight vision.

This is the phase you are in when conducting most military night operations or driving around in a car at night. It occurs at dawn or dusk, down to full moonlight. It occurs when there is artificial illumination, or with snow on the ground at night. It can also occur in the daytime with several layers of jungle canopy.

You are still using central and peripheral vision but you are using both rods and cones. The cones are used, but less than in daylight.



Twilight Vision - continued

- Poorer visual acuity
- Poorer color vision
- Poorer reaction time

SLIDE 23: **Twilight Vision (continued)**

This is the second and last slide on twilight vision. It parallels the second slide on daylight vision. Note that in each case, an individual's ability to see has diminished under twilight conditions--poorer acuity and color vision, and slower reaction times.

An effective instruction technique with this slide is to ask students if the slides are clear to them (see Possible Script below). At this point in the program, most individuals have 20/50 - 20/100 visual acuity due to the reduced light levels.

Possible Script:

Because of the lower light levels at dawn, dusk, and full moon conditions, your visual acuity is poorer. Visual acuity can be as poor as 20/100.

Do these slides look clear to you? These slides are actually in focus but because you are under reduced lighting conditions the visual system cannot appreciate them as clear. The best visual acuity you can hope to obtain is between 20/50 and 20/100.

You also have poorer color vision. You can still see colors but they won't be as vivid.

In addition, you have slower reaction times, also because of the reduced lighting levels.

Night Vision

- Stars or no moon
- Night blind spot
- Rods only

SLIDE 24: **Night Vision**

The final stage of dark adaptation--night vision--is covered in the next two slides. It is also known as scotopic vision. Stress the conditions under which this will occur and that the "night blind spot" is present.

Possible Script:

The final dark adaptation stage is night vision.

This occurs under starlight, as well as on moonless and cloudy nights when there aren't any stars or cultural lighting.

There is a "night blind spot" because only rods are being used. As demonstrated earlier, the "night blind spot" will cause objects to vanish when you stare at them.

Night Vision - continued

- Worse visual acuity
- Silhouette recognition only
- No color vision
- Worse reaction time

SLIDE 25: **Night Vision (continued)**

Stress the consequences of night vision as listed in the slide.

Possible Script:

Under night conditions everyone has the worst visual acuity. The best visual acuity is from 20/200 to 20/400 and possibly much worse. You can recognize silhouettes, but not the details of objects. Thus troops need to be taught silhouette recognition of vehicles, natural, and man-made objects.

You have no color vision. If you can see colors, it's not night vision. You can tell the color of a bright flare under starlight conditions, but that is because the flare is bright enough to activate your cone cells, and thus your color vision.

You also have the slowest reaction time, because you are only using rod cells. No cone cells are used for night vision.

Dark Adaptation

- Takes 30 - 45 minutes
- Increasing rod sensitivity
- Restores visual purple

SLIDE 26: **Dark Adaptation**

The next slides explain more about the actual process of dark adaptation. This information provides the rationale for how you can dark adapt efficiently, and how you can protect your dark adaptation during night operations.

Stress that the time to totally dark adapt takes from 30-45 minutes. Many individuals mistakenly believe the time is much shorter. More information on visual purple is presented on the next slide.

Possible Script:

In order for your visual system to work efficiently at night, you need to dark adapt. That's what you are doing while sitting in this dark room. It takes about 30-45 minutes to fully dark adapt or get your eyes used to seeing things under low light conditions. You are talking about going from a brightly lighted area into the dark. It takes longer to dark adapt than many people think.

If you are in the field from day light to night time, you dark adapt as the light level decreases. When you wake up in the middle of the night, your eyes are dark adapted.

Many people want to know how long it takes to dark adapt after wearing night vision goggles. The Army literature says it takes 2 minutes to gain full dark adaptation if you had dark adapted before putting on your goggles. However, this was based on research where individuals wore goggles for only 5 minutes. The time required to dark adapt after wearing goggles for a longer period of time, such as 2 or 4 hours, has not been investigated yet, but is most likely greater than 2 minutes.

Let's get back to the process of dark adaptation. What's happening? The sensitivity of the rod cells increases during dark adaptation. This is done by restoring a chemical called visual purple.

Visual Purple

- Vitamin A
- Light bleaching effects
- Increases in darkness

SLIDE 27: **Visual Purple**

Because visual purple is essential to your ability to see at night, it is important that ground forces understand its characteristics (see information in Possible Script below). An effective instruction technique is to point out that the students can now see shadows and other objects in the room which were not previously visible because the amount of visual purple in their rod cells has increased. A more technical name for visual purple is rhodopsin.

Possible Script:

You might have heard the term visual purple. It is found only in the rod cells. You need visual purple to see at night.

Visual purple is a derivative of vitamin A which has special light bleaching effects. When light hits visual purple, there is a photochemical response. An electrical impulse is sent to the brain. The brain interprets this impulse as light, and the visual purple is bleached out or depleted.

As you sit in a dark room the amount of visual purple actually increases because there is no light to "bleach out" the visual purple.

If you look around this room now, you can see shadows and other things that you couldn't see a few minutes ago, simply because the amount of visual purple has increased in the rod cells.

When going from a bright to a dark area, the cones dark adapt relatively quickly, about 3 to 4 minutes, but the rods take longer. Thus, when going into a movie theater, it doesn't take too long to see the theater seats. But it is the change in the rods, the increased sensitivity of the rods over a 30 to 45 minute period that enables you to see really well in the dark.

Protecting Dark Adaptation Before Night Operations

- No smoking
- Wear sunglasses when in bright conditions
- Nutrition
- Dim lighting

SLIDE 28: **Protecting Dark Adaptation <u>Before</u> Night Operations**

The next two slides discuss the importance of adequately preparing to dark adapt prior to night operations and how to maintain dark adaptation once in the field. The major points to stress are:

- Smoking can cause hypoxia, or lack of oxygen to the blood. The rod cells are very susceptible to this condition.

- It is important to wear sunglasses when out during daylight conditions (see example in Possible Script on next page).

- Vitamin A supplements are poisonous to the eyes. Stress that vitamin A supplements should not be used; stress having a balanced diet. Use the examples described in the Possible Script.

- Appropriate lighting is essential to the success of missions. Stress the examples provided in the Possible Script to explain the best lighting combinations.

Possible Script:

It is very important to protect your eyes before night operations so that you can dark adapt in an efficient manner. We have a few suggestions to help you dark adapt more efficiently.

If you smoke, we recommend you don't smoke prior to night time operations. Not smoking 4 - 6 hours prior to night operations will aid in dark adaptation. It has been suggested that smoking may cause hypoxia. Hypoxia is a deficiency in the amount of oxygen in your tissues. It decreases the rod cells' ability to dark adapt effectively and efficiently. This results in an increased time to dark adapt.

We recommend wearing sunglasses if you are going to spend time out in the sun, whether it be sand, snow or just a bright day. Studies have shown that people going out on a beach without sunglasses took 3-4 hours to dark adapt while people wearing sunglasses took between 30-45 minutes. This occurs because all the visual purple is bleached out of the rod cells due to all of the bright sunlight. Wearing military issue sunglasses was advised for ground forces in previous combat operations.

Another suggestion is to watch what you eat. Good nutrition is important in order to maintain adequate levels of vitamin A. You will get enough vitamin A in your normal diet if you eat dairy products, leafy vegetables, and poultry. Independent Vitamin A supplements should not be used. Too much of it can cause bleeding in the back of your eyes.

Before jumping from planes, typically red lights are used at least 10 to 20 minutes before the jump in order to allow troops to dark adapt. In some cases, no lights are used during flight, but red lights are turned on shortly before the jump so troops can see the jump master.

Dim white lighting has advantages over any other color if you are going to be briefing in a confined space and need to look at charts and photos prior to night operations. A single 40 watt light bulb in a medium (15 x 15 foot) size space is just about right.

Protecting Dark Adaptation During Night Operations

- Minimize bright light use
- Avoid looking directly at bright lights
- Close one eye when around bright lights

SLIDE 29 **Protecting Dark Adaptation During Night Operations**

Every individual on the ground must know how to remain dark adapted in order to be effective at night. The points made on this slide are critical. Failure to understand or apply them can lead to being temporarily non-functional at critical times on the battlefield.

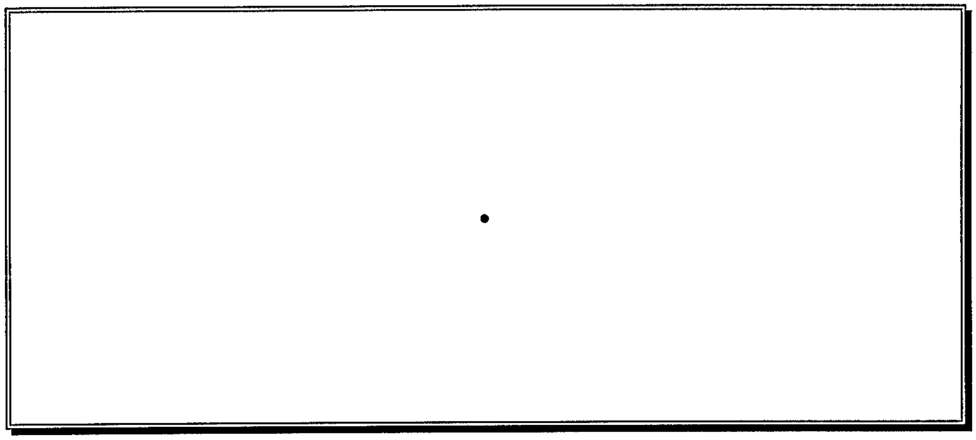
Possible Script:

Once you are dark adapted, it's also important to maintain that dark adaptation.

One of the things we recommend is to minimize your use of unnecessary lighting. That does not mean to avoid using lights when looking at charts or other navigational aids. It does mean turn the lighting down to a point where it is comfortable for you to see things without glare all around.

Minimize your bright exterior lights. This guidance is also consistent with the need to maintain light discipline at night. If you don't need to use headlights, search lights, or flash lights, don't. If you happen to be in a brightly lit area, other lighting is often not necessary. By all means NEVER COMPROMISE YOUR SAFETY. Remember it is more difficult for others to see dim red lights from a distance than white or green lights.

If you know you are going to be exposed to bright lights, such as parachute flares, headlights, cannon bursts, or searchlights, close one eye prior to being flashed. This will preserve your dark adaptation. We will demonstrate this later.



SLIDE 30: **Autokinesis Illusion**

The autokinetic illusion is the illusion of movement which a static light exhibits when stared at in the dark. It is related to a loss of surrounding visual references which normally serve to stabilize visual perceptions. The small eye movements which create the illusion are normal. This illusion can be eliminated or reduced by using visual scanning techniques, increasing the number of lights, or by varying the light intensity.

Use the following demonstration procedures to create the illusion:

- Direct the students' attention to the single, dim white light on the screen. Point out that the illusion may occur with any color light, however.

- Have students stare at the single light. Suggest a direction of movement by asking, "In which direction is the light moving?" or "I see it moving up to the right." Permit about 8 - 10 seconds for development of the illusion.

NOTE: If students perceive no movement, request that they continue to stare in the direction of the light. Shut off the projector, pause and then turn it on again. This will also intensify an already perceived illusion.

See Possible Script on next page.

Possible Script:

On the screen, there is a small white dot of light. You may have to look off to the side a bit to see it.

If you stare directly at it, the dot may disappear.

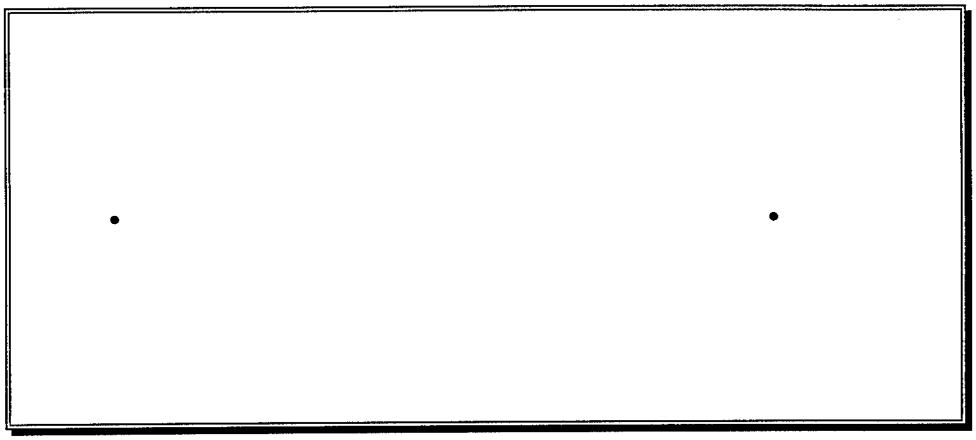
The dot might also start to move up and to the left a bit, or down to the right. (Pause 8 to 10 seconds). When it starts to move, you are experiencing the autokinesis illusion. In which direction is the light moving for you? (Pause)

What you are experiencing is an illusion, an illusion of movement. The light is not moving at all. This illusion, called Autokinesis, occurs because there is a lack of visual cues in your field of vision. Consequently, very small eye movements are perceived by the brain as movement of the light.

This light could be a chem light or cigarette of an enemy soldier. Is the enemy moving, or is it your eyes?

This is a very strong illusion which has caused several aviation accidents. People have been known to follow lights like this thinking they were actual moving objects such as vehicles or airplanes. People on the ground have also reported becoming disoriented because of this illusion.

Under such conditions, the best thing people can do is to begin a scan pattern and control their eye movements.



SLIDE 31: **Autokinesis Illusion (continued)**

This slide demonstrates how an additional light or a reference light will decrease the extent of the autokinetic illusion.

- Tell the students to look at one of the dots. When it starts moving, tell them to start scanning between the two dots. The movement should now stop.

You can mention that staring at a group of multiple lights can produce or intensify the autokinetic illusion. It is only decreased when the other light is used as a reference. In other words, gaze must be shifted back and forth.

Possible Script:

If you look at the screen now there are two lights, one on the left and one on the right. Look at one of the two lights.

When that light starts to move, I would like you to start scanning between the two dots and see what happens to the movement. (Pause).

Simply by scanning or controlling your large eye movements, you will be able to control the movement.

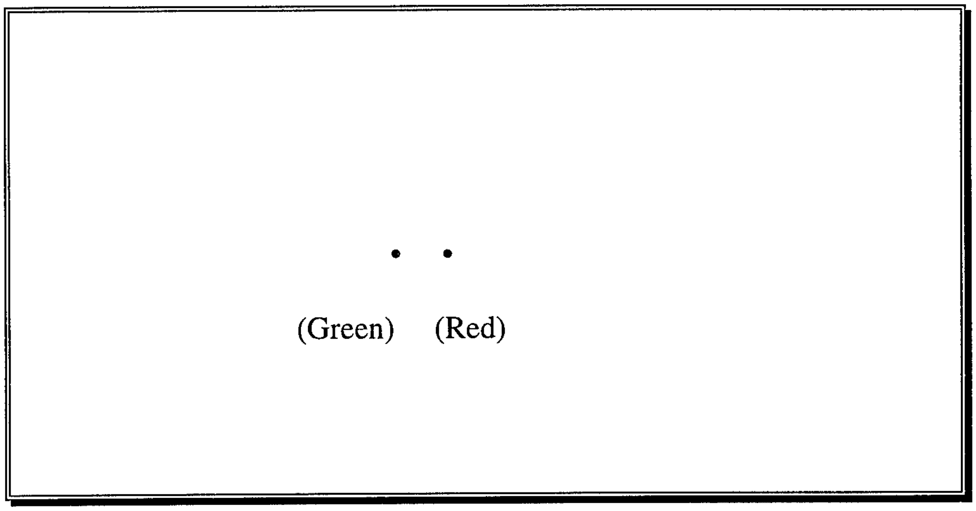
Situations in which autokinesis can occur include:

- observing a single ground based light at night, particularly if you are elevated.

- looking at a prominent bright star.

- a single approach light of distant aircraft coming directly at you.

Pathfinders always mark aircraft landing zones with at least two lights which are widely separated to prevent this visual illusion.



SLIDE 32: **Purkinje Shift**

This slide demonstrates the sensitivity of the eye to different colors at night. As you approach night vision (very low illumination), your eye is more sensitive to blue-green lights, simply because the peak sensitivity of the rods is different from that of the cones. This phenomenon is particularly important to ground forces when using different colored signals and markers during night operations. These signals and markers can be used more effectively when the peculiarities of color vision are considered.

However, no specific measurements are cited for the distances at which the Purkinje effect is likely to occur in the field with commonly used marking and signaling devices. For instance, the distances for which colored light sources such as red and orange chem strobes can fade or disappear or the distances at which blue-green chem lights can appear white are not cited. These will vary with the brightness of the light source, the amount of ambient light at night, etc.

Because much information supports this slide, it requires more preparation time than many of the others to ensure none of the material is omitted during the presentation.

Use the following demonstration technique with this slide:

- Have students view centrally, staring directly between both lights. Note that they look about the same brightness.

- Now have the students gaze 20 - 30 degrees up; the red light will dim. Ask the students which light dims first in the periphery. They should report RED. (This occurs because the rods are more sensitive than cones to the blue-green wavelength. When viewing off 20 - 30 degrees, they are utilizing only a few cones and more rods.)

- Ask the students if the green light still appears green, or does it just appear white. If it still appears green, have them view more peripherally.

- Emphasize that lights can appear white when viewed by the peripheral visual system. Ground forces must be aware of the fact that if white lights are seen off in the distance, they can be colored chemlights, oncoming vehicles, or navigational lights of aircraft.

- Emphasize to the students that under dark adapted conditions, the wavelength of blue-green light can be seen from the greatest distance using their peripheral vision. This is why it is important to utilize red lights in the field if you are trying to stay camouflaged. Blue-green chemlights will be visible over the greatest distances.

Possible Script:

Looking at the slide now on the screen, you see a red and green dot. If you look directly between the dots, both dots should look equally bright. Do they look about the same brightness? (Pause).

Slowly look up toward the ceiling or off to the side and tell me what happens to the brightness of the green dot and the brightness of the red dot. (Pause). The green one gets brighter.

Now I would like you to look all the way up to the ceiling or side until the green dot turns white. What you are experiencing is called the Purkinje Shift. Your cone cells, the ones located on the foveal or central portion of the retina, are most sensitive to longer wavelengths of light, like reds. The rod cells are most sensitive to the shorter wave-lengths of light, like greens.

When you are looking directly at the dots, they look about the same brightness. But as you look off peripherally you are exposing more of the image to your rod cells on the periphery of the retina, causing the greens to appear brighter.

The danger of this is that if you see a white light off in the periphery you may conclude that it is white, rather than green or another color. On large LZs, where different colored strobe lights were used to designate different company assembly areas, troops have indicated that the colors of the strobes disappear. The take home message is this: if you see a white light off in the periphery, don't assume it's white. Look directly at the light to determine exactly what color it is. If the light is moving, keep your eye on it to at least figure out what the relative motion of the image is so you can actually ascertain whether or not it is coming toward you or moving away from you.

Additionally, under dark adapted conditions, therefore, blue and green can be seen from the greatest distance using peripheral vision. This is why green and blue strobe lights are easier to see from a distance than amber or orange strobes. This is why red is the best color light to use when trying to maintain camouflaged.

As demonstrated to you, colors are often difficult to see at night. This is particularly true on drop zones and landing zones. Pathfinders often use a distinct pattern of lights instead of different colored lights for marking purposes. For example, lights which form the shape of different letters are used to designate different drop zones. A specific pattern of lights is used to indicate when a mission is canceled.

If you have a specific picture of what colors will look like during the day, you must realize that colors will not look the same at night. Colored smoke and red landmarks will be invisible. Blue-greens can appear white.

A red lens flashlight is recommended for use at night when reading maps in the field. This is because the red lens does not affect your dark adaptation as much as other colors.

In order to see red markings on a map, many US maps are made "red-light readable." Why is this necessary? When you are using the red lens in your flashlight at night, the only light shining on your map is red light. The white background on the map reflects the color red to your eyes as do the red lines themselves. The red lines "disappear." Most US maps are now "red-light readable" and are so labeled in the legend. However, many maps of foreign countries are not. If in doubt about the red lines on a map, you can check whether they are red-light readable during the day by covering yourself with a poncho and seeing if the red lines "vanish." If the red markings and lines are not red-light readable, then you will need to use a clear lens to see the red at night. However, it is essential to maintain light discipline under these conditions, and to reduce the white light signature of your flashlight as much as possible to maintain dark adaptation.

SLIDE 33: **Night Horizon**

INSTRUCTIONS: Several demonstrations are conducted with this slide. You also need three props: the aircraft model, the tank model, and the strobe light. When conducting the demonstrations you must be near the projection screen, not behind the projector or at the back of the room. In addition, the room lights must be turned on for a short period of time.

Use the following demonstration technique with this slide:

- Have the students stare directly at several of the landmarks on the landscape. The silhouettes at which they are staring should either partially or totally disappear. This demonstrates the "night blind spot."

- Now have the students look to the left or right of the silhouette they were staring at (about 10 degrees). The landmark will fall on their peripheral visual field and they will now be able to identify it.

- Choose a landmark easily identifiable by a common shadow, such as the church or school with flagpole. Demonstrate the value of and requirement for silhouette recognition.

- Have the students stare at the radio tower in the middle of the screen. Introduce air and land moving targets by walking in front of the screen

with the hand held shadows (models). Insure that your movement is at a fairly slow rate. The target should disappear as it passes the tower. Now have the students look directly at the target, which again will disappear. It will be almost impossible to pick out fine detail because students will be using scotopic or rod vision.

- Remind students at this point that:

1. If clouds are present, airborne targets may be concealed within their borders.

2. With increased haze conditions there will be a loss of contrast and detail; consequently, targets can be missed.

3. There is a loss of depth perception at night.

Strobe Demonstration:

- Activate the strobe light, and walk across the room with the light flashing. Emphasize to the students that this is used for night rescue operations and, if a person does not stare directly into the flash, the light will not disrupt dark adaptation due to its microsecond flash duration.

- Demonstrate the fact that dark adaptation has not been adversely affected by the strobe. Turn the strobe off and have the students pick out targets on the silhouettes projected on the screen.

- Note that the xenon strobe is also being utilized as an anti-collision light on many civilian and military aircraft, as well as on some vehicles. Reemphasize that staring into direct flash at close range can reduce dark adaptation no matter what the flash duration is.

- Small arms fire of short duration will not reduce dark adaptation appreciably. However, rocket fire, mini-gun fire, or exposure to a flash or searchlight beam for a longer duration than one second may cause temporary loss of night vision.

Floodlight Demonstration

- Have students close and cover the left eye with the palm of the left hand, leaving their right eye open.

- Direct their attention to the front of the room, and emphasize that the hand must continue to occlude vision in the left eye.

- Explain that a person might do this when working with flares, refueling on the ground, and when floodlights are being used, in lightning storms, etc.

- Turn on photoflood light (or room lights) for 10 seconds. Encourage students to look near the light with their right eye.

- Turn off the photoflood light (or room lights). Direct the students' attention to the silhouettes on the screen with their left eye still covered. Ask if they see any silhouettes. Emphasize their flash blindness and unilateral loss of dark adaptation.

- Instruct the class to remove their hand from the left eye and emphasize that they have retained full dark adaptation with the covered eye. Direct their attention to the silhouettes. They will be able to see them at this point with the left eye only.

- Explain that night vision will gradually return to the right eye since the flood light was only on for a short duration.

See Possible Script on next page.

Possible Script:

On the screen in front of you is a landscape. Tell me what you see. (Pause).

What type of trees are there? Do you see wires between the telephone poles? Look at the tower on top of the hill and tell me what you see. (Pause).

Notice that you can see silhouettes easily and can take advantage of this. Objects with distinct silhouettes or outlines are good target reference points. In an urban environment, buildings with unique architectural features, such as a church with a steeple, can be identified easily. Many vehicles and other targets such as bunkers also have distinct outlines.

On the other hand, if you can see silhouettes and distinctive outlines, so can the enemy. There are many examples of how ground forces apply this to their advantage to reduce the likelihood of being detected by the enemy. When moving as a platoon, squad, team or individual, you avoid "skylining." When preparing defensive positions, you position and camouflage them so they will not present a distinctive silhouette.

PLANE OR TANK DEMONSTRATIONS:

I am going to move a plane over the tower. Look at the tower.

<u>**Instructions: Walk slowly in front of the screen holding the model in front of you.**</u>

As you look at the tower, what happens to the plane as the plane goes directly over the tower? Parts of the plane should disappear.

Now try to follow the plane by looking directly at it. What happens? (Pause). It disappears. That's because of your "night blind spot."

Now try to follow the tank moving along the hillside by looking directly at it. What happens? It also disappears.

Now use the "Diamond viewing" technique to follow the tank. It is easily visible. If you look peripherally you can still see it. Now look directly at the tank; it disappears.

This is not just important with moving objects. Look at the church, then the steeple. If you look directly at the steeple on the church, what happens to the church? (Pause). It becomes a house, because the steeple disappears.

Even if you are looking for images that you have seen in pictures or photographs, like potential targets, you still need to use your peripheral retina to actually see the silhouette. If you look directly at the target, your eyes may deceive you. It is important to keep alert at night, to scan the terrain and horizon in front of you.

STROBE DEMONSTRATION

Ground forces often use strobe lights for signaling and marking. Flashlights are flashed quickly when clearing rooms. Let's see how such lights affect dark adaptation. Continue to look at the screen.

Instructions: Walk around the front of the room with the strobe light on. After 8 to 10 seconds turn the strobe off.

I have now turned on a strobe light and will leave it on for 8 to 10 seconds. Do not look directly at the strobe.

Can you still see the landmarks on the screen? (Response should be "yes.") This demonstrates that your dark adaptation has not been adversely affected by the strobe. The duration of the strobe is quick. It does not actually bleach out the rod cells, especially if you do not look directly at it.

Similarly, small arms fire of short duration, tracers, or someone turning on a strobe next to you will not reduce dark adaptation appreciably. Your dark adaptation is not going to be adversely affected unless you look directly at these lights. However, rocket fire, mini-gun fire or exposure to a flash or search light beam for a duration longer than one second may cause temporary loss of night vision.

FLOODLIGHT DEMONSTRATION

Now I would like everyone to close and cover your left eye with the palm of your hand. Leave your right eye open.

Instructions: Turn the overhead lights ON for 10 seconds

Now look at the overhead light with your right eye. This simulates sudden exposure at night to a flood light, a search light, or vehicle lights which were accidentally turned on. What should you do in such a situation?

Instructions: Turn room lights OFF.

Keep your left eye covered and look at the silhouettes on the screen. Do you still see the silhouettes? Are they as clear as before? (Should not be as clear.) You have experienced flash blindness in your right eye.

Now uncover your left eye and look at the screen. The silhouettes should be visible and clear. Simply by covering one eye you are able to preserve your dark adaptation.

Now cover the left eye again. What can you see on the screen with only your right eye? (Pause.) Remember your right eye just experienced flash blindness.

Now uncover it. If you have already been dark adapted, it doesn't take 30 to 45 minutes to dark adapt again. It takes a shorter amount of time. This is important to know because if this should happen to both your eyes, your dark adaptation will come back relatively quickly. If you compare the two eyes, you may see a difference between them, but your dark adaptation should be just about the same in both eyes.

Colors Play Tricks

- Colors can appear as white
- Blues/greens appear brighter
- Blue/green visible greater distances
- Reds difficult to see

SLIDE 34: **First Summary Slide - Colors Play Tricks**

The four summary slides stress the points and techniques that individuals should remember and use when planning, preparing and executing night tasks and missions. They will help reduce some of the problems, confusion, and frustration experienced at night.

Possible Script:

Remember that colors can play tricks on you at night.

Colors can appear as white when seen peripherally.

Blues and greens will always appear brighter than reds or other colors.

Because blues and greens will appear brighter, they will be visible over greater distances.

In general, reds will be more difficult to see at night. Red objects will be invisible, and red lights will not be seen over great distances.

To Protect Vision

- Wear sunglasses
- Avoid smoking
- Balanced diet
- Be physically fit and rested

SLIDE 35: **Second Summary Slide - How to Protect Vision**

Stress the points made on the slide.

Possible Script:

Before night operations, remember to wear sunglasses and avoid smoking. This will decrease the time it takes for you to dark adapt.

To enhance your overall performance and help you remain alert, maintain a balanced diet and be physically fit and rested prior to participating in night operations.

Remember, exhausted people tend to stare, and that can degrade your night vision.

To Maintain Vision

- View to the side of objects
- Use diamond viewing
- Minimize bright lights
- Close one eye

SLIDE 36: **Third Summary Slide - To Maintain Vision**

Stress the points made on the slide.

Possible Script:

During night operations it is important to maintain your ability to see. Scan, don't stare. View to the sides of objects using diamond viewing or off center viewing to avoid the "night blind spot."

Minimize the use of bright lights.

If you expect to be exposed to bright lights, close one eye and don't look directly at the lights. This will preserve your dark adaptation.

To Maximize Vision
• Diamond viewing • Silhouette recognition • Wear glasses at night • Colored signals/ markers look different

SLIDE 37: **Fourth Summary Slide - To Maximize Vision**

Stress the points made on the slide.

Possible Script:

Maximize the night vision capabilities you have learned today by remembering to:

Use diamond viewing to look at targets and other areas of interest.

Use your ability to see silhouettes to your advantage. Often, this is the best vision you will have at night.

Wear your clear prescription glasses at night in order to see as well as possible.

Use different colors for signaling and marking from sources such as chemlights and flares. These typically provide light that is sufficiently bright to trigger your color vision.

SLIDE 38: **Troops**

This slide will demonstrate the effects of time on dark adaptation.

- Explain that this was the first slide which was projected at the beginning of the lecture. The illumination level is identical.

- Emphasize that time is important in dark adaptation.

Possible Script:

Now you have been sitting in this room for about 30 minutes and have dark adapted. I'm going to show you the first slide I originally put on the screen.

Remember, no one was able to see this when you first started. By just sitting in the room and letting your eyes naturally dark adapt, they have increased their sensitivity to light by about 100,000 times.

Now you can see the slide very clearly because your eyes have adapted to the dark.

INSTRUCTIONS: At the end of the presentation go backwards through the slides to the original troop picture. This allows everyone to see how much more distinct the words and letters in the slides are, once they have dark adapted.

I'M TURNING ON THE ROOM LIGHTS NOW, SO WATCH YOUR EYES!

HELP, ASSISTANCE, AND SUGGESTIONS

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Glossary of Terms/Concepts

Autokinesis: When a person gazes at a single light source at night, the light will soon appear to move. This movement is generally attributed to involuntary movements of the muscles which control the eye.

Accommodation: The ability of the crystalline lens to change shape, allowing for focusing of objects at different distances, primarily those closer than 20 feet.

Central Blind Spot: This is the same as the "Night Blind Spot." It is present only at night, under starlight or less light conditions. It is located in the central area and is caused by an absence of rods in the fovea and the inability of the cone cells to function under very dark conditions.

Cones: Light receptors located in retina, but concentrated in the foveal or central area. Responsible for color vision and discriminating visual acuity (20/20; 20/15).

Cornea: Clear portion of the outer coat of the eyeball. Responsible for a majority of light bending, allowing for focus of images on the retina.

Depth Perception: The perception of relative or absolute difference in distance of objects from the observer. This can be achieved by using such cues as motion parallax, object overlap, convergence of parallel lines, and relative size of objects.

Diamond Viewing: Method of peripheral or off center viewing used to counter the "night blind spot." By perceptually placing a diamond in space around an object, and then moving one's eyes around the diamond, images which normally would be invisible because of the "night blind spot" will be visible.

Fovea: The center of the macula area, which is responsible for clear, crisp vision. Cone cells are concentrated in this area of the retina.

Hypoxia: An oxygen deficit in the body, which can be caused by exposure to high altitudes without supplemental oxygen, smoking and other chemicals. Results in increased time for dark adaptation.

Iris: The colored part of the eye, located behind the cornea, but in front of the lens. The hole in the middle of the iris is called the pupil.

Macula: Uniquely pigmented area of the retina which contains the highest concentration of cone cells. The center of the macula is called the fovea.

Mesopic Vision: This is the same as twilight vision. It is the state of dark adaptation which occurs during low light conditions. Still using cones to see, but because there is less light, rod cells are also being utilized. The range of clear vision during mesopic vision is approximately 20/50 - 20/100, depending upon the individual and how much light is available.

Photopic Vision: This is the same as daylight vision. It is the state of dark adaptation which occurs during maximum lighting conditions. Only cone vision is used. People have their best visual acuity, best color vision, and quickest reaction time under photopic conditions.

Physiological Blind Spot: This is the same as the "normal blind spot." It is caused by the insertion of the optic nerve in the back of the eye and the subsequent absence of retinal light receptors in that area.

Purkinje Shift: This is the shift in retinal sensitivity from yellow to blue-green when going from a light adapted to dark adapted state. Rods are more sensitive to blue-green than cones. Cones are more sensitive to longer wavelengths of light like yellow and red.

Pupil: This is the hole in the middle of the iris which allows light to pass from the outside of the eye to the inside of the eye. The pupil gets smaller when there is a great deal of light and larger when there is less light.

Rods: Light receptors located in retina, but not located in the foveal or central area. Rods function under low light conditions. Responsible for peripheral and night vision. Best visual acuity is about 20/200.

Refractive Error: A focusing defect in the eye that prevents light rays from being focused clearly on the retina.

Retina: Layer in the back of the eye which is composed of light-sensitive cells. It is broken down into central and peripheral retina. Central retina is responsible for discriminating visual acuity, while the peripheral retina is responsible for peripheral vision and night vision.

Rhodopsin: Also known as visual purple, rhodopsin is the chemical located in rod cells which allows for the cells to discriminate small amounts of light. It accumulates in the cells only under dark conditions; a process which takes about 30 - 45 minutes.

Scotopic Vision: This is the same as night vision. It is the state of dark adaptation which occurs during minimum lighting conditions. Only rod vision is used. The best visual acuity is 20/200. There is also a "night blind spot." In order to see well under scotopic conditions, dark adaptation is necessary.

Visual Acuity: Description of detailed central vision. Generally noted as a fraction, such as 20/20, where the top number is the distance an observer is from the chart and the bottom number is the size of the letter being looked at.

Visual Purple: Same as rhodopsin.

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APPENDIX B

JOB AID

UNAIDED NIGHT VISION GUIDELINES

"DR. SAFE" and "EYE SAFE"

BEFORE OPERATIONS PMCS	
DR	USE DIM WHITE OR DIM RED LIGHT
S	WEAR SUNGLASSES
A	AVOID SMOKING
F	BE FIT AND RESTED
E	EAT RIGHT

DURING OPERATIONS PMCS	
E	EXERCISE LIGHT DISCIPLINE
Y	YOUR PRESCRIPTION GLASSES MUST BE WORN
E	EXPECT BRIGHT LIGHTS -- CLOSE ONE EYE
S	SCAN -- DON'T STARE
A	ALLOW TIME TO REGAIN DARK ADAPTATION
F	BEWARE OF FADING OR FALSE COLORS
E	BE AN EXPERT IN SHAPES AND SILHOUETTES

BASIC FACTS ON UNAIDED NIGHT VISION

UNDER THESE CONDITIONS		
DAYLIGHT	TWILIGHT OR FULL MOON	NO MOON OR STARS ONLY

THE CONSEQUENCES FOR MILITARY OPERATIONS ARE		
GOOD ACUITY	POOR ACUITY	BAD ACUITY
SEE GREATEST DETAIL	SEE LESS DETAIL	SEE OUTLINES ONLY
		NIGHT BLIND SPOT WHEN YOU STARE
COLORS ARE VIVID	COLORS LESS VIVID	NO COLOR VISION
	RED LIGHTS HARDEST; BLUE/GREEN EASIER, MAY APPEAR WHITE	
GOOD REACTION TIME	SLOWER REACTION TIME	SLOWEST REACTION TIME

THESE VISUAL DIFFERENCES OCCUR BECAUSE THE EYE IS USING		
ALL CONES	CONES & RODS	RODS ONLY
CENTRAL & PERIPHERAL VISION	CENTRAL & PERIPHERAL VISION	PERIPHERAL VISION ONLY
	Use of rods means poorer acuity and less vivid colors.	Dark adaptation is reduced when rods are exposed to bright light. Dim red & dim white light maintain dark adaptation.

APPENDIX C

CONTENT SUMMARY

UNAIDED NIGHT VISION FOR GROUND FORCES

Co-Developed By

Naval Aerospace Medical Research Laboratory
Pensacola, FL

Naval Aerospace and Operational Medical Institute
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1995

The purpose of this booklet is to present basic facts on how your eye operates at night and the implications of this for military night operations. Direct applications and guidance for ground forces and key points are in **bold print**.

Even when night observation devices are available, there are always circumstances where ground forces must operate without them; that is, with "unaided night vision." The information in this booklet describes visual illusions and problems which are common at night, why they occur, and techniques to deal with them. The purpose is to provide you the information necessary for maximizing your unaided night vision, and guidelines for your night operations SOPs.

This booklet complements the Unaided Night Vision Program, a 35-mm slide presentation conducted in the dark which provides actual demonstrations of visual problems and illusions you encounter at night. It can be used either before or after seeing the program.

THE LIMITATIONS OF NIGHT VISION

Although operating at night has definite advantages, it is also difficult. Your eyes do not work as well as during the day, yet they are critical to your performance. You need to be aware of the constraints your eyes place upon you at night, because eighty (80) percent of your sensory input comes through them. What are some of these constraints or limitations?

- Your ability to see crisp and clear images, your visual acuity, is reduced.
- Under certain conditions, you cannot distinguish one color from another.
- Your depth perception is reduced.
- You have a "night blind spot" which makes it difficult to see objects at certain distances.
- Lights can cause you to lose your dark adaptation.
- Your eyes may seem to play tricks on you.

There are ways to reduce these night vision problems. Certain scanning techniques allow you to see objects more clearly. There are techniques for protecting your dark adaptation from different types of lights.

THE HUMAN EYE

In order to better understand how the eye works at night you need to learn about the parts of the eye and how they function at night.

<u>Cornea</u>

Light enters the eye through the clear portion of the eye called the cornea. The cornea has the major responsibility of bending light so that it focuses clearly on the back of the eye. The cornea is also very sensitive to pain. If you get a piece of sand in your eye, the cornea is what hurts. When you wear contact lenses, the contact lenses fit over the cornea.

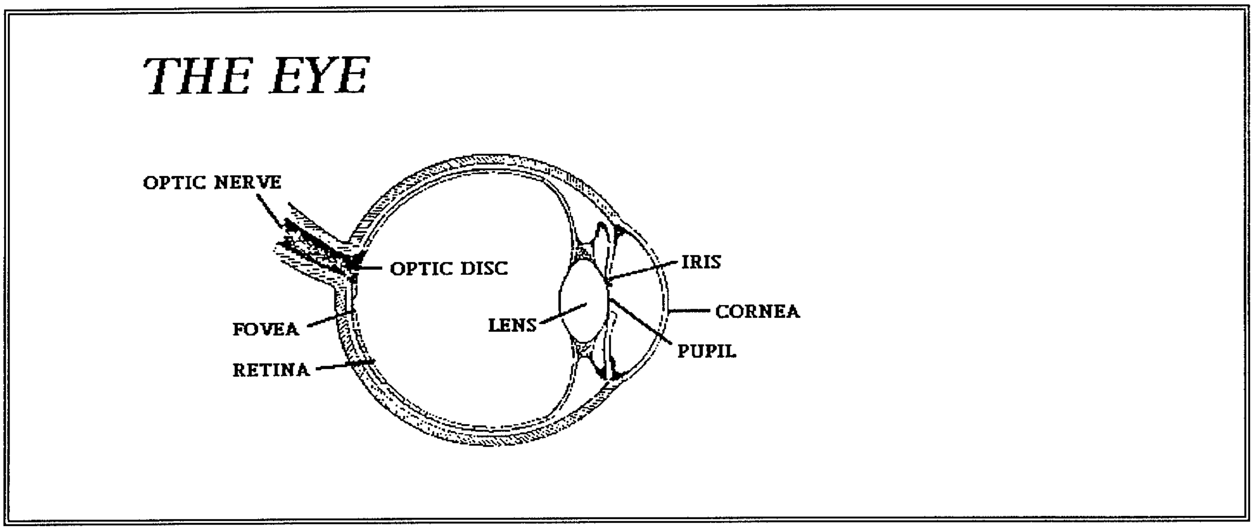
<u>Iris</u>

Behind the cornea is the colored part of the eye called the iris.

<u>Pupil</u>

In the middle of the iris is a hole, called the pupil. In bright sunlight, the pupil gets smaller. This small pupil size helps light to focus clearly on the retina. **However at night, the pupil gets larger in order to let more light into the back of the eye. When the pupil enlarges, light which normally might focus clearly on the back of the eye may focus imperfectly because of the eye's imperfect optics. This is especially noticeable if you need glasses to see clearly. Even individuals with weak prescription glasses, who may not need their glasses to see clearly during daylight, need glasses to see clearly at night. As the pupil becomes larger, the eye cannot focus as easily. Wearing glasses at night helps to counter this effect.**

Thus, it is very important for individuals with weak prescriptions to wear their glasses at night in order to see the best they can.



Lens

The lens is the saucer-shaped structure directly behind the pupil. The lens has a couple of different functions. First and foremost, the lens helps to focus light on the back of the eye.

Second, **the lens gives you the ability to focus on objects located closer than 20 feet.** This is called accommodation. When you look at things up close, the shape of the lens changes, causing it to work as a magnifier. This is how the eye adjusts its focus so that objects 16 to 20 inches away become clear. Unfortunately, as individuals get older, this process of accommodation doesn't work as efficiently. **People who are over the age of 40 have more difficulty focusing on close objects.** This occurs because the lens does not change shape as easily. Therefore, older people need to wear reading glasses or bifocals.

The lens focusing system does not work well at night, causing blurred images. Under night time conditions, the lens fails to totally eliminate this blur. Additionally, under red lighting conditions, it is even more difficult to focus because red lights make individuals more farsighted. Therefore, dim white light may be the better light to use in TOCs and other situations where close-work such as reading is required.

Retina

When light finally gets to the back of the eye, it focuses on the area called the fovea, the central part of the retina. **The fovea is responsible for good crisp vision. The rest of the retina is called the peripheral retina. It is used for peripheral vision and is primarily responsible for night time or dark vision.**

There are two types of light receptors on the retina -- cones and rods. The cones are concentrated in the center (the fovea) and exist on the peripheral retina as well. They decrease in number away from the fovea. On the other hand, there are no rods on the fovea. They are located only on peripheral retina and increase in number away from the fovea.

Optic Nerve

The peripheral retina is also where the optic nerve inserts in the back of the eye, connecting the eye to the brain. There are no light receptors at this point, resulting in a "normal blind spot."

CONE CELLS AND ROD CELLS

The cone cells are primarily responsible for daytime vision, while the rod cells are primarily responsible for night vision. Most of the differences between daytime and night time vision result from the fact that rods and cones function differently.

Cone Cells

Cone cells function during the day and under full moonlight at night. **If the light level gets below full moonlight, the cone cells cannot function.**

The **cone cells are responsible for good, clear, crisp vision**; 20/20 or 20/15 visual acuity. What does having **20/20 vision** mean? It means that if an object is placed at 20 feet, a person with 20/20 vision can see it clearly at that distance. On the other hand, if you have 20/100 vision, that means that you can see at 20 feet what someone with 20/20 vision can see at 100 feet. You must be closer to the object to see it clearly. **The bottom line is that if the second number is big, your vision is poor; you have problems and need glasses to correct these problems.**

Cone cells are **responsible for color vision**. They also facilitate very accurate depth perception. They are **fast acting**, which means as soon as they sense light, it is processed back to the brain.

There are approximately 7 million cone cells located throughout the retina; that is, throughout the back of the eye. The cone cells are located everywhere on the retina, but are concentrated on the fovea or the area of central vision where your best visual acuity occurs. In fact, the cone cells are the only cells on the fovea, and are responsible for the "Night Blind Spot."

Rod Cells

The rod cells are most effective at night. They are sensitive to very small amounts of light, which is why they work so effectively for night vision. **Rod cells are not used for central vision**. They are not on the fovea. They are located only on the periphery of the retina.

Although there are 20 times more rod cells (approximately 120 million) than cone cells, the visual acuity with rod cells is 10 times worse than that which can be obtained with cone cells.

The **best visual acuity with rod vision is about 20/200; that's seeing the big "E" on an eye chart! What does this mean for your night vision when there is little moonlight or starlight available? 20/200 acuity means that an object which you could see clearly during the day from a distance of 200 feet requires you be 20 feet away to see it clearly at night.**

Colors cannot be seen with rod cells. They just see black, white, and shades of gray. Rods **react more slowly** to visual stimuli than the cones. This means that it takes longer for the light signal to be processed in the rods and sent to the brain.

NORMAL BLIND SPOT

The "normal blind spot" is always present, day and night. It is caused by the lack of light receptors where the optic nerve inserts into the back of the eye. The "normal blind spot" occurs when you use just one eye. When you close the other eye, objects about 12 to 15 degrees off from where you are looking will disappear. When you uncover your eye, the objects will reappear.

Why don't we experience such blind spots during the day during normal work? The "normal blind spot" is not really a factor unless you only have one eye. The visual fields of both eyes overlap so that what one eye doesn't see, the other eye does see. Therefore, you will never notice the "normal blind spot."

There are certain times at night when you must cover an eye to preserve your dark adaptation. During these times, you will be using only one eye, and therefore must compensate for the "normal blind spot" by scanning more vigorously.

NIGHT BLIND SPOT AND VIEWING TECHNIQUES

When you stare at an object at night, under starlight or lower levels of illumination, it can disappear or fade away. This is a result of the "night blind spot." You need to know what you can do to overcome it. It affects both eyes at the same time and occurs when using the central vision of both eyes.

Why do you have a "night blind spot"? When you stare at something, you are using your central vision, the central part of the retina, the fovea. The only light receptors on that part of the retina are the cones, and they do not function under low levels of illumination. The rod cells, which do function at night, are not in the central part of the retina. Consequently, you cannot see objects at night when you stare at them; that is, when using your central vision.

What are the **consequences of the "night blind spot" for military operations? Larger and larger objects are missed as distances increase**. A hand grenade at 2 meters from your eyes might not be seen. An enemy soldier at 50 meters might not be seen; a howitzer at 100 meters. An M1 tank at 330 meters might be missed. You may miss something as large as a C-13O aircraft 1,000 meters away. So, if you are looking directly at something at night, you may miss it because of the "night blind spot." When following others at night in a file, individuals have

reported reflective tape on the back of helmets disappearing, and that staring at small chem lights caused them to disappear.

In order to avoid the "night blind spot," there is only one thing to do: look to all sides of objects you are trying to find or follow. Do not stare! This is the only way for you to maximize your night vision. **A good technique for peripheral viewing is called "diamond viewing."** It is similar to the off-center vision technique taught in rifle marksmanship. Diamond viewing means that you move your eyes just slightly, a few degrees, in a diamond pattern around the object you wish to see. You do not have to move your head. Use your peripheral vision.

Diamond viewing is exactly the opposite of what you have always done to see something clearly in the day. In the day you look more intently at an object or stare to see it more clearly. At night you should look around objects to see them clearly. The problem at night is that you can become fatigued or stressed. Under these conditions, you may resort to staring, which is what you have habitually done to see an object more clearly. For example, when concerned about a possible break in contact while moving, you may tend to stare at the person in front of you to avoid losing contact. You should do just the opposite - use a scanning pattern, such as diamond viewing to maximize your ability to see troops and other objects of interest in front of you. However, you need to practice this technique to become proficient with it at night. Even while moving, troops have reported it is better to use peripheral vision when looking at persons to their front. You see them more clearly. In addition, scanning helps you see tree limbs, signals, and holes in the ground at night.

At night, you cannot see details of objects, but you can see silhouettes easily and can take advantage of this. Objects with distinct shapes or outlines are good target reference points. In an urban environment, buildings with unique architectural features, such as a church with a steeple, can be identified easily. Many vehicles and other targets such as bunkers also have distinct outlines.

If you stare directly at a landmark, it may partially or totally disappear. This is due, once again, to the "night blind spot." If you look to the left or right of the landmark, it will fall on the peripheral visual field, and will consequently come back into view. Even if you are looking for images that you have seen in pictures or photographs, like potential targets, you still need to use your peripheral retina to actually see the objects at night. If you look directly at a target, your eyes may deceive you, and a portion of that target may not be visible to you. It is important to keep alert at night, to scan the terrain and horizon in front of you. Use a scanning technique such as diamond viewing.

On the other hand, if you can see silhouettes and distinctive outlines, so can the enemy. There are many examples of how ground forces apply this to their advantage to reduce the likelihood of being detected by the enemy. When moving as a platoon, squad, team or an individual, moving on top of a ridge is to be avoided. When preparing defensive positions, position and camouflage them so they will not present a distinctive silhouette.

THREE STAGES OF ADAPTATION

There are three stages of dark adaptation which help to explain how the eye works at night.

Daylight Vision

The first stage is daylight vision; the technical term is photopic vision. This occurs under maximum lighting conditions such as when the sun is shining or in a well lit room. Under these conditions, both your central and peripheral vision are used, but it is all cone vision. There is no rod vision. Because it is only cone vision, you have your best visual acuity; that is 20/10, 20/15, and 20/20 vision. You have your best color vision. Colors look most vivid under daylight conditions. You also have your quickest reaction time because you are using all cone cells.

Twilight Vision

The next stage of adaptation is twilight vision, technically known as mesopic vision. **Twilight vision occurs during many military night operations and when driving around in a car at night. It occurs at dawn and dusk, down to full moonlight. It also occurs when there is artificial illumination and when snow is on the ground at night. It can occur in the daytime with several layers of jungle canopy.**

You still use central and peripheral vision during twilight vision, but you now use the rods as well. The cones are used, but less than in daylight. Because of the lower light levels at dawn, dusk, and full moon conditions, your **visual acuity is poorer**. Visual acuity can be as poor as 20/100. In fact, the **best visual acuity you can hope to obtain under twilight conditions is between 20/50 and 20/100.**

You also have **poorer color vision. You can still see colors but they won't be as vivid**. In addition, you have **slower reaction times**, also because of the reduced lighting levels.

Night Vision

The final stage is night vision, technically known as scotopic vision. **Night vision occurs under starlight, as well as on moonless and cloudy nights when there are no stars or cultural lighting. There is a "night blind spot" because only rods are being used.**

Under night conditions, everyone has the worst visual acuity. The best visual acuity is from 20/200 to 20/400 -- and possibly much worse. You can recognize silhouettes, but not the details of objects. This is why you need to know the silhouettes of vehicles and critical natural or man-made objects.

You have no color vision. If you can see colors, it's not night vision. If you can tell the color of a bright flare under starlight conditions, that is because the flare is bright enough to activate your cone cells, and thus your color vision. Under low levels of illumination or night vision only various shades of gray can be seen. Colors will not look green, red, or yellow; they just appear

as varying shades of gray. **With night vision, the longer wavelengths of light, such as the reds and oranges, are hard to see and will appear dark. Unless a dark color is bordered by two lighter colors, it becomes totally invisible. Reds will be almost invisible at night. The reason red crosses are on white backgrounds on tents or vehicles is so they can be more easily seen at night. On the other hand, green and blue lights will appear brighter, although you may not be able to determine their color.** Under higher levels of illumination at night, you may perceive many more colors.

You also have the **slowest reaction time** because you are only using rod cells. No cone cells are used for night vision.

DARK ADAPTATION

In order for your visual system to work efficiently at night, you need to dark adapt. **It takes about 30 to 45 minutes to fully dark adapt or get your eyes used to seeing things under low light conditions,** when going from a brightly lighted area into the dark. It takes longer to dark adapt than many people think. It's similar to walking into a movie theater when it's very dark. You can't see things at first. Your eyes will gradually adapt, enabling you to see more and more as time goes on. In addition, **people dark adapt at varying rates. People who are a little older, people who smoke, or people who may not be in great physical shape will take longer to dark adapt or see things under low light conditions.**

If you are in the field from daylight to night time, you dark adapt as the light level decreases. When you wake up in the middle of the night, your eyes are dark adapted.

Your dark adaptation is affected by night vision goggles. The Army literature says it takes 2 minutes to gain full dark adaptation if you had dark adapted before putting on your goggles. However, this was based on research where individuals wore goggles for only 5 minutes. The time required to dark adapt after wearing goggles for a longer period of time, such as 2 or 4 hours, has not been investigated yet, but is most likely greater than 2 minutes.

During dark adaptation the sensitivity of the rod cells increases. This is done by restoring a chemical called visual purple. You might have heard the term visual purple. It is found only in the rod cells. You need visual purple to see at night. Visual purple is a derivative of Vitamin A, which has special light bleaching effects. When light hits visual purple, there is a photochemical response. An electrical impulse is sent to the brain. The brain interprets this impulse as light, and the visual purple is bleached out or depleted. As you sit in a dark room, the amount of visual purple actually increases because there is no light to "bleach out" the visual purple.

When going from a bright to a dark area, the cones adapt relatively quickly, in about 3 to 4 minutes, but the rods take longer. Thus, when going into a movie theater, it doesn't take too long to see the theater seats. But it is the change in the rods, the increased sensitivity of the rods over a 30 to 45 minutes period, that enables you to see really well in the dark.

PROTECTING DARK ADAPTATION BEFORE NIGHT OPERATIONS

It is very important to protect your eyes before night operations so you can dark adapt in an efficient manner. Some suggestions are given which will help you dark adapt more efficiently.

Don't smoke prior to night time operations. Not smoking 4 to 6 hours prior to night operations will aid in dark adaptation. It has been suggested that smoking may cause hypoxia. Hypoxia is a deficiency in the amount of oxygen in your tissues. It decreases the rod cells' ability to dark adapt effectively and efficiently. **Smoking results in an increased time to dark adapt.**

Wear sunglasses if you are going to spend time in the sun, whether it be sand, snow, or just a bright day. **Without sunglasses, it will take longer to dark adapt**. Studies have shown that people going out on a beach without sunglasses took 3 to 4 hours to dark adapt while people wearing sunglasses took between 30 to 45 minutes. This occurred because the visual purple was bleached out of the rod cells from the bright sunlight. Wearing military issue sunglasses was advised for ground forces in previous combat operations.

Another suggestion is to watch what you eat. **Good nutrition is important in order to maintain adequate levels of Vitamin A**. You will get enough Vitamin A in your normal diet if you eat dairy products, leafy vegetables, and poultry. **Independent Vitamin A supplements should not be used**. Too much of it can cause bleeding in the back of your eyes.

Use dim white lighting or dim red lighting before night operations. Before jumping from planes, typically red lights are used at least 10 to 20 minutes before the jump in order to allow time for troops to dark adapt. In some cases, no lights are used during flight, but red lights are turned on shortly before the jump so troops can see the jump master. Dim white lighting has advantages over any other color if you are going to be briefing in a confined space and need to look at charts and photos prior to night operations. A single 40 watt light bulb in a medium (15 x 15 foot) size space is just about right.

PROTECTING DARK ADAPTATION DURING NIGHT OPERATIONS

Once you are dark adapted, it's also important to maintain that dark adaptation. **Minimize your use of unnecessary lighting to maintain your dark adaptation during night operations**. You can still use lights when looking at charts or other navigational aids, but turn the lighting down to a point where it is comfortable for you to see things without glare all around.

Minimize bright exterior lights. If you don't need to use headlights, search lights, or flashlights, don't. If you happen to be in a brightly lit area, other lighting is often not necessary. By all means **never compromise your safety. Remember it is more difficult for others to see dim red lights from a distance than white or green lights.**

If you know you are going to be exposed to bright lights, such as parachute flares, headlights, cannon bursts, or searchlights, **close one eye prior to being flashed by flares and other bright lights to preserve your dark adaptation**.

If you do not stare directly into a brief flash of light, such as a strobe or tracers, the light will not disrupt your dark adaptation. You will still be able to identify landmarks and silhouettes. Ground forces often use strobe lights for signaling and marking. Flashlights are flashed quickly when clearing rooms. The duration of the strobe is quick; the duration of flashes is only a microsecond. Small arms fire of short duration and tracers will not reduce dark adaptation appreciably. These quick flashes of light do not bleach out the visual purple in the rod cells, especially if you do not look directly at them. However, rocket fire, mini-gun fire or exposure to a flash or search light beam for a duration longer than one second may cause temporary loss of night vision.

You can preserve your dark adaptation when suddenly exposed to a flood light, a search light, or vehicle lights. Close one eye. You will experience a temporary flash blindness in your other eye. When the light source is gone and you uncover your eye, your vision in that eye should be clear. Simply by covering one eye you are able to preserve your dark adaptation.

If you have already been dark adapted, it doesn't take 30 to 45 minutes to dark adapt again after being flash blinded. It takes a shorter amount of time. If this should happen to both your eyes, your dark adaptation will come back relatively quickly.

AUTOKINESIS ILLUSION
(Apparent movement of light)

The autokinesis illusion is the illusion of movement which a static light exhibits when stared at in the dark. It is related to the loss of surrounding visual references which normally serve to stabilize visual perceptions. Consequently, very small eye movements are perceived by the brain as movement of the light.

What are the consequences of the autokinesis illusion? Is the light you see in the field at night could be a chem light, the cigarette of an enemy soldier, or is it your eyes? This is a very strong illusion which has caused several aviation accidents. Aviators have been known to follow lights like this thinking they were actual moving objects such as another plane. People on the ground have also reported becoming disoriented because of this illusion. Under such conditions, the best thing people can do is to begin a scan pattern and control their eye movements. **Use large eye movements and scan to control autokinesis. Try to find another light and shift your gaze back and forth between the lights.**

The autokinesis illusion can occur in the following situations:
- observing a single ground based light at night, particularly if you are elevated
- looking at a prominent bright star
- a single approach light of distance aircraft coming directly at you

Pathfinders always mark aircraft landing zones with at least two lights which are widely separated to prevent the autokinetic illusion.

COLORS AT NIGHT

The eye reacts differently to colors under reduced illumination than during the day. **With night vision (very low illumination), your eye is more sensitive to blue-green lights, simply because the peak sensitivity of the rods is different from that of the cones. When you look at a red and green light with your peripheral vision, the red light will be dim, and sometimes disappear, and the green dot will be brighter, sometimes almost white**. This is called the Purkinje Shift. This phenomenon is particularly **important to ground forces when using different colored signals and markers during night operations. These signals and markers can be used more effectively when the peculiarities of color vision are considered.**

As mentioned previously, colors are not perceived by the rods. However, the rods are more sensitive than cones to the shorter wavelengths of light, like greens. When viewing something peripherally, you are using only a few cones and more rods. Your cone cells, the ones located on the fovea or central portion of the retina, are most sensitive to longer wave-lengths of light, like reds. Thus, when using your peripheral vision, you are exposing more of an image to your rod cells, causing any greens to appear brighter. Additionally, under dark adapted conditions, blue and green can be seen from the greatest distance using peripheral vision. This is why green and blue strobe lights are easier to see from a distance than amber or orange strobes, even though the different colors can not be distinguished with night vision (i.e., rods only).

The critical point is that if you see a white light with your peripheral vision, don't assume it is white. Look directly at it to determine the color; use your central, cone vision because the cones provide color vision. If the light is sufficiently intense and/or sufficiently close, it may activate your cones cells and color may be perceived.

The Purkinje shift can affect night operations. For example, troops have indicated that when different colored strobe lights were used on large landing zones to designate different company assembly areas, the colors of the strobes disappeared and it was not possible to distinguish one assembly area from another.

Because colors are often difficult to see at night, pathfinders often use a distinct pattern of lights instead of different colored lights for marking purposes. For example, lights which form the shape of different letters are used to designate different drop zones. A specific pattern of lights is used to indicate when a mission is canceled. **If you have a specific mental image of what colors will look like during the day, you must realize that colors will not look the same at night. Colored smoke and red landmarks can be invisible. Blue-greens can appear white.**

A red lens flashlight is recommended for reading maps in the field because the red lens does not affect your dark adaptation as much as other colors. However, in order to see red markings on a map, **maps must be "red-light readable."** Why is this necessary? When you

are using your red lens in your flashlight at night, the only light shining on your map is red light. The white background on the map reflects the color red to your eyes as do the red lines themselves. The red lines "disappear." Most US maps are now "red-light readable" and are so labeled in the legend. However, many maps of foreign countries are not. If in doubt about the red lines on a map, you can check whether they are red-light readable during the day by covering yourself with a poncho and seeing if the red lines "vanish." If they do, then you will need to use a clear lens to see the red markings at night. However, it is essential to maintain light discipline under these conditions, and to reduce the white light signature of your flashlight as much as possible to maintain dark adaptation.

SUMMARY

Colors Play Tricks

- Colors can appear as white when seen peripherally.
- Blues and greens will always appear brighter than reds or other colors. Because blues and green will appear brighter, they will be visible over greater distances.
- In general, reds will be more difficult to see at night. Red objects can be invisible and red light cannot be seen over great distances.

How to Protect Vision

- Before night operations, remember to wear sunglasses and avoid smoking. This will decrease the time it takes to dark adapt.
- To enhance your overall performance and help you remain alert, maintain a balanced diet and be physically fit and rested prior to participating in night operations.
- Exhausted people tend to stare, and that can degrade your night vision.

How to Maintain Vision

- Scan, don't stare. View to the sides of objects using diamond viewing or off center viewing to avoid the "night blind spot."
- Minimize the use of bright lights.
- If you expect to be exposed to bright lights, close one eye and don't look directly at the lights. This will preserve your dark adaptation.

How to Maximize Vision

- Use diamond viewing to look at targets and other areas of interest.
- Use your ability to see silhouettes to your advantage. Often, this is the best vision you will have at night.
- Wear your clear prescription glasses at night in order to see as well as possible.
- When using different colors for signalling and marking, be sure the light sources are sufficiently intense to trigger your color vision at the desired distances.

APPENDIX D

SOURCES OF RESEARCH ON UNAIDED NIGHT VISION

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